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December 1961

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SECTION I. — AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

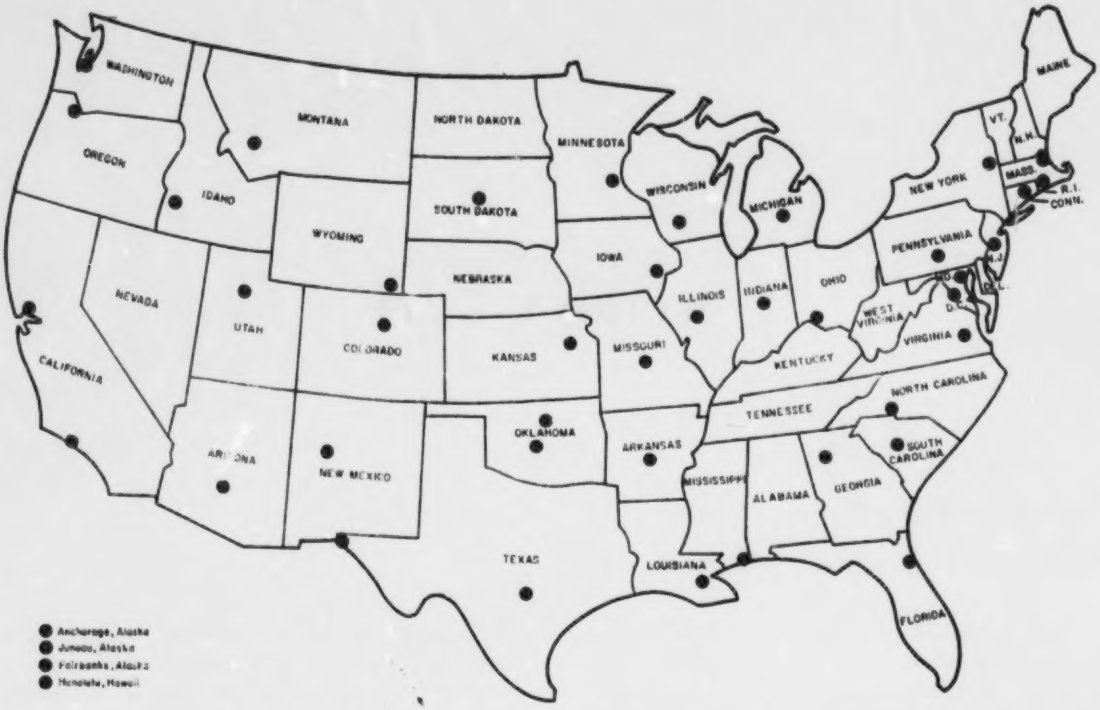
The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. During the period reported, it consists of 45 stations at urban locations (see figure 1) opperated by State and local health department personnel with 2 of the stations operated by Public Health Service personnel.

Measurements of gross beta radioactivity in air are taken as they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The station located at Atlanta, Georgia, conducts its own laboratory analyses.

Air samplers were in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a cellulose carbon-loaded dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples.

Values for May 1961 as presented in table 1 are generally below limits of detection by present instrumentation.

Due to the resumption of nuclear weapons testing, a renewed interest in the results of the Radiation Surveillance Network has been evidenced. Field measurements of gross beta determinations from stations showing increased readings have been released by the Public Health Service and published almost daily by newspapers. Table 2 presents confirmed daily laboratory results for the first 18 days of September for stations selected to provide geographical coverage. The results for June, July, and August will be published as soon as possible.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MASS.
VT.
N.H.
MAINE
● Anchorage, Alaska
● Juneau, Alaska
● Fairbanks, Alaska
● Honolulu, Hawaii

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR, MAY 1961 GROSS BETA DETERMINATIONS

Station location	Number samples	Maximum ($\mu\mu c/m^3$)	Minimum ($\mu\mu c/m^3$)	Average[1] ($\mu\mu c/m^3$)
Anchorage, Alaska	22	0.36	<0.10	<0.15
Fairbanks, Alaska	20	0.27	<0.10	<0.15
Juneau, Alaska	14	0.35	<0.10	<0.16
Phoenix, Ariz	2	0.24	0.23	0.23
Little Rock, Ark	21	0.22	<0.10	<0.14
Berkeley, Calif	18	<0.10	<0.10	<0.10
Los Angeles, Calif	20	0.17	<0.10	<0.11
Denver, Colo	15	0.23	<0.10	<0.14
Hartford, Conn	31	0.34	<0.10	<0.14
District of Columbia	25	0.29	<0.10	<0.16
Jacksonville, Fla	23	0.23	<0.10	<0.16
Atlanta, Ga	14	0.21	<0.10	<0.12
Honolulu, Hawaii	22	0.14	<0.10	<0.10
Boise, Idaho	8	0.27	<0.10	<0.17
Springfield, Ill	9	0.26	<0.10	<0.14
Indianapolis, Ind	31	0.26	<0.10	<0.15
Iowa City, Iowa	22	0.25	<0.10	<0.15
Topeka, Kans	23	0.22	<0.10	<0.14
New Orleans, La	1	0.14	0.14	0.14
Baltimore, Md	21	0.31	<0.10	<0.15
Lawrence, Mass	19	0.20	<0.10	<0.12
Lansing, Mich	31	0.31	<0.10	<0.17
Minneapolis, Minn	9	0.23	<0.10	<0.13
Pascagoula, Miss	19	0.38	<0.10	<0.15
Jefferson City, Mo	22	0.30	<0.10	<0.14
Helena, Mont	22	0.30	<0.10	<0.15
Trenton, N. J	16	0.26	<0.10	<0.16
Santa Fe, N. Mex	17	0.38	<0.10	<0.23
Albany, N. Y	17	0.22	<0.10	<0.14
Gastonia, N. C	23	0.30	<0.10	<0.17
Oklahoma City, Okla	20	0.26	<0.10	<0.17
Ponca City, Okla	29	0.18	<0.19	<0.11
Portland, Oreg	23	0.21	<0.10	<0.12
Harrisburgh, Pa	18	0.24	<0.10	<0.14
Providence, R. I	20	0.24	<0.10	<0.15
Columbia, S. C	7	0.15	<0.10	<0.13
Pierre, S. Dak	8	0.30	<0.10	<0.18
Austin, Tex	23	0.25	<0.10	<0.14
El Paso, Tex	20	0.57	0.16	0.31
Salt Lake City, Utah	30	0.30	<0.10	<0.15
Richmond, Va	22	0.22	<0.10	<0.13
Seattle, Wash	22	0.12	<0.10	<0.10
Madison, Wis	28	0.28	<0.10	<0.16
Cheyenne, Wyo	8	0.16	<0.10	<0.13

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

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TABLE 2.—RADIOACTIVITY OF PARTICLES IN AIR—DAILY SAMPLES AT SELECTED RADIATION SURVEILLANCE NETWORK STATIONS, SEPTEMBER 1–18, 1961

[Concentrations in μμc/m³]

Station location	Sept. 1	Sept. 2	Sept. 3	Sept. 4	Sept. 5	Sept. 6	Sept. 7	Sept. 8	Sept. 9	Sept. 10	Sept. 11	Sept. 12	Sept. 13	Sept. 14	Sept. 15	Sept. 16	Sept. 17	Sept. 18
Anchorage, Alaska	<0.10	[a] NS	NS	NS	7.73 [c](5)	9.5 (4)	0.20	<0.10	<0.10	0.22	0.11	0.18	1.05 (5)	2.87 (5)	2.19 (15)	0.3	1.27 (7)	2.05 (10)
Los Angeles, Calif.	<0.10	<0.10	[b]—	<0.10	<0.10	<0.10	<0.10	<0.10	1.72 (6)	1.72 (8)	0.14	0.96 (9)	1.18 (14)	1.58	0.82 (15)	0.81	0.56 (8)	0.70 (10)
Washington, D. C.	<0.10	<0.10	<0.10	<0.10	<0.10	0.22	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.46 (11)	0.85 (12)	1.27 (6)	63.73 (6)	23.49 (8)
Jacksonville, Fla.	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	—	1.30 (11)	4.02 (13)	401.16 (8)
Springfield, Ill.	<0.10	—	—	—	—	—	<0.10	—	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	0.59 (17)	1.40 (15)	2.51 (10)	NS
Topeka, Kans.	<0.10	NS	NS	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	<0.10	—	1.10 (13)	1.88 (15)	2.16 (16)	2.36 (20)
New Orleans, La.	NS	<0.10	NS	<0.10	<0.10	—	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.57 (9)	0.98 (15)	1.31 (15)	1.69 (14)	297.07 (8)
Lansing, Mich.	—	—	—	—	—	—	—	<0.10	<0.10	<0.10	<0.10	<0.10	0.11	—	0.67 (13)	1.99	38.34 (7)	35.83 (10)
Minneapolis, Minn.	NS	NS	NS	<0.10	NS	NS	<0.10	<0.10	<0.10	<0.10	<0.10	0.15	—	—	—	1.23 (20)	2.26 (16)	1.99
Albany, N. Y.	<0.10	—	—	—	—	—	—	—	<0.10	<0.10	<0.10	<0.10	0.74	0.15	0.62 (12)	NS	58.21 (7)	14.12 (8)
Gastonia, N. C.	<0.10	NS	NS	NS	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	—	1.09 (10)	NS	106.50 (6)	80.31 (9)
Austin, Tex.	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	NS	0.75 (14)	2.23 (12)	2.16 (11)	4.78 (15)
Salt Lake City, Utah	<0.10	<0.10	<0.10	<0.10	<0.10	—	<0.10	<0.10	0.89 (6)	<0.10	4.2 (18)	6.20 (11)	15.0 (12)	14.37 (13)	5.10 (15)	0.73 (15)	0.59 (9)	0.26
Seattle, Wash.	<0.10	—	—	—	NS	<0.10	<0.10	<0.10	0.31 (11)	<0.10	<0.10	<0.10	0.92 (11)	3.48 (6)	0.92 (10)	0.48	0.32	0.41 (6)

[a] NS, No sample.
[b] —Not known.
[c] Figures in parentheses denote age of fission products in days.

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Surface Air Radon, Thoron, and Fission Product Gross Beta Concentrations at Cincinnati, Ohio

Robert A. Taft Sanitary Engineering Center, Public Health Service

Natural background radioactivity in our atmosphere is an important public health consideration because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially produced radionuclides. Natural radioactivity in surface air is attributed to a number of unstable nuclides other than those produced by man. The earth's crust contains trace amounts of uranium and thorium that occur naturally and which decay through a series of their daughter products. These decay products of uranium and thorium are introduced into surface air through their rare gas daughters, radon (radon-222) and thoron (radon-220), which in turn continue to decay through the uranium and thorium series, respectively. The radon and thoron content of air depends on the escape of these rare radioactive gases from the earth. Concentrations depend on prevailing atmospheric conditions such as ambient temperature, humidity, and pressure, and on soil conditions such as moisture, porosity and temperature.

Most of the natural radioactivity in surface air is due to radon (Rn^{222}) and its daughters. Thoron (Rn^{220}) and its daughters contribute much less because of thoron's short half-life and hence, a lower diffusion rate from the soil.

The Radiological Health Research Activities, Research Branch, Division of Radiological Health, Public Health Service, performs a continuous daily sampling program for radon (Rn^{222}), thoron (Rn^{220}), and gross beta fission product concentrations in surface air. The gross beta activity of atmospheric particulates, when measured several days after sample collection, is principally due to artificially produced radionuclides.

Air is filtered through a membrane filter, and the daughter products of radon and thoron, which are particulates, are deposited on the filter. Measurements of the alpha activity on the filter are related to the concentrations of radon or thoron in surface air. Most of the activity of radon daughters, that have a composite half-life of approximately 0.5 hour, would decay to 0.5 percent of the original value in less than four hours. The activity of thoron daughters that have a composite half-life of 10.6 hours, would decay to 0.5 percent of its original value in about four days. For this reason the gross beta determinations are made at least four days after the end of each sampling period.

Radon-222 concentrations are determined from alpha measurements made immediately after the sampling period (24 to 72 hours) has ceased. Reported radon-222 (a.m.) concentrations have been corrected for any radon-220 daughter interferences. Radon-222 (p.m.) concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. These values are from the same filters that are counted at 8 a.m. the following day. Reported radon-222 (p.m.) concentrations are uncorrected for any radon-220 daughter interferences. Radon-220 concentrations are determined from alpha measurements made on the same sample used to evaluate the corrected radon-222 (a.m.) concentrations, but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder.

There has been a recent change in the reporting period because the data are now computed by an electronic data processing system which is programed for thirteen four-week periods per calendar year. The data for the period May 22–June 16, 1961 appear in table 1.

REFERENCE

Setter, L. R. and Coats, G. I., "The Determination of Airborne Radioactivity," American Industrial Hygiene Association Journal, Vol. 22, Number 1, February 1961.

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TABLE 1.—SURFACE AIR RADON, THORON, AND FISSION PRODUCT GROSS BETA CONCENTRATIONS, MAY 22–JUNE 16, 1961

End of sampling period	Continuous sample collection			Rn^{222} [a] 8 a.m. ($\mu\mu c/m^3$)	Rn^{222} [b] 3 p.m. ($\mu\mu c/m^3$)	Rn^{220} [c] ($\mu\mu c/m^3$)	Beta [d] activity ($\mu\mu c/m^3$)
	Sample change time	Sample period (hours)	Volume (m^3)				
May 22	0809	72.0	85.1	160	40	3.1	0.15
23	0806	24.3	29.5	390	70	3.6	0.13
24	0816	24.1	29.5	570	70	4.8	0.11
25	0809	23.8	29.0	390	110	5.1	0.16
26	0806	23.9	28.8	70	60	1.8	0.12
29	0806	71.9	87.3	370	160	5.1	0.10
31	0807	48.0	56.6	820	110	2.6	0.21
June 1	0830	24.4	29.0	280	170	4.4	0.21
2	0802	23.5	28.5	200	200	3.3	0.20
5	0804	72.0	86.4	670	240	7.4	0.11
6	0817	24.1	29.3	230	100	2.5	0.06
7	0804	23.7	28.4	360	120	4.1	0.23
8	0805	24.0	28.4	150	120	2.2	0.08
9	0804	23.9	28.3	140	110	1.3	0.11
12	0807	72.0	85.0	700	170	6.3	0.09
13	0800	23.9	28.1	330	160	3.0	0.23
14	0804	24.0	28.3	180	130	1.3	0.06
15	0800	23.9	28.2	70	50	0.8	0.00
16	0800	23.9	28.6	160	40	1.1	0.04
Average				327	120	3.4	0.13

[a] Twice the standard deviation (2σ) falls between ±14 and ±51 $\mu\mu c/m^3$.
[b] Twice the standard deviation (2σ) falls between ±10 and ±27 $\mu\mu c/m^3$.
[c] Twice the standard deviation (2σ) falls between ±0.3 and ±0.9 $\mu\mu c/m^3$.
[d] Twice the standard deviation (2σ) falls between ±0.01 and ±0.07 $\mu\mu c/m^3$.

SAMPLING PROGRAMS FOR RADIOACTIVITY IN AIR

The following articles are the third and fourth in a series of papers intended to present summaries or selected discussions concerning atmospheric levels of radioactivity. The first of the two presented here discusses and statistically compares the surface air fission product gross beta concentrations analytically defined by two Public Health Service atmospheric sampling programs—the National Air Sampling Network (NASN), Division of Air Pollution, and the Radiation Surveillance Network (RSN), Division of Radiological Health. The data, analysis and discussion were compiled and prepared by Dr. Bernard Shleien and Mr. Thomas A. Entzminger of the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio.

This statistical comparison, performed on data from a selected number of sampling points over a specified period of time, shows that different sampling techniques and analytical procedures performed by different laboratories will influence the fission product gross beta concentrations reported by the respective sampling programs. The specific location of the air samplers are subject to considerations such as local climatological and topographical factors. No attempt has been made to determine the relative effect which each of these considerations contributes to the variations observed.

The authors wish to express their appreciation to the Divisions of Air Pollution and Radiological Health, Public Health Service, for their cooperation, and for supplying the basic data necessary for this analysis.

The second article, by Major Albert K. Stebbins, III, USAF, presents a discussion and partial summary of the most extensive stratospheric air sampling program ever performed. Known as the High Altitude Sampling Program (HASP), it is operated by the Defense Atomic Support Agency (DASA), Department of Defense. In this program, U-2 aircraft collected particulate debris on filter papers at altitudes up to 70,000 feet.

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Data derived from HASP provides:

(1) stratospheric inventories of strontium-90 in the Northern and Southern Hemispheres during 1958, early and late 1959, and early 1960

(2) a hypothetical model of stratospheric mixing and transfer processes, and

(3) a limited comparison of the hazard from fallout of past weapons tests.

A Comparison of Surface Air Fission Product Gross Beta Concentrations—National Air Sampling Network and Radiation Surveillance Network

Public Health Service

The Public Health Service operates two surface air fission product gross beta sampling programs—the National Air Sampling Network (NASN) and the Radiation Surveillance Network (RSN). The principal objectives of the NASN are to develop adequate sampling procedures and to determine the amounts of specific organic and inorganic pollutants, including nuclear bomb debris, in representative air samples which are collected at urban and non-urban sites on a randomized sampling schedule. The responsibility of the RSN is to provide an immediate evaluation of environmental fission product gross beta levels, on a daily basis, at selected sampling sites. These semi-quantitative field results are then confirmed by a laboratory analysis.

Comparison of Sampling Techniques and Methods

The sampling techniques and analytical procedures employed by these two programs for evaluating surface air fission product gross beta concentrations differ. Since no field determinations are made on NASN samples, only the laboratory results have been considered in this study.

The NASN samples are obtained with high-volume air samplers which employ an 8″ x 10″ glass fiber filter capable of removing almost 100 percent of all particulates with diameters equal to or greater than 0.3 microns. The average sampling rates at urban stations range from 40 to 50 cfm. The volume of air filtered in a normal 24 hour sampling period usually averages 2000–2200 cubic meters (*1*). RSN air samples are collected with similar high-volume air samplers, but they are fitted with 4″ diameter MSA BM 2133 dust filters (*2*). The volume of air drawn through a 24 hour RSN sample is approximately 40% less than that for a NASN sample. This is probably due to greater loss of head pressure through the felt fiber filters used in RSN samplers.

The NASN samples sent to the Robert A. Taft Sanitary Engineering Center are equilibrated overnight at 75° F and 50 percent relative humidity; they are weighed, and counted for their gross beta fission product content. Similar gross beta counts are made two to four days after collection, and again four to six days later. This facilitates an extrapolation to date of collection. Gross beta activities are measured by placing the entire 8 x 10-inch filter beneath a 7.5 inch diameter thin window (Mylar) proportional gas-flow counter (NMC–PCC12) that has an over-all efficiency of about 35 percent. Uranium oxide on a 2 inch diameter stainless steel planchet is used as a secondary standard (*3*). The secondary standard is covered with an aluminum foil (7 mg/cm^2) to shield out the alpha activity.

RSN samples are counted for their respective gross beta activity in a 7.5 inch diameter thin-window proportional gas-flow counter (same type as above) three to five days after collection. Determinations are made by comparison to a 0.02 μc Sr^{90}-Y^{90} source deposited on a 4 inch diameter plastic disk. A second count is made seven days after the first, and the results are extrapolated to the date of collection (*2*).

In order to relate the laboratory determinations, data were compared for cities in which samplers of both programs were at the same location. The sites were New Orleans, Wash-

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TABLE 1.—AVERAGE SURFACE AIR FISSION PRODUCT GROSS BETA CONCENTRATIONS (1958) AND CORRELATION COEFFICIENTS FOR THE NASN AND RSN AIR SAMPLES COLLECTED AT THE SAME LOCATIONS

Station	Number of samples	Correlation coefficient (RSN-NASN)	NASN ($\mu\mu c/m^3$)	RSN ($\mu\mu c/m^3$)	Ratio $\left(\frac{NASN}{RSN}\right)$
Anchorage, Alaska	20	0.98	2.5	1.8	1.4
Cheyenne, Wyo	18	0.92	9.9	4.4	2.2
Little Rock, Ark	21	0.90	5.2	4.6	1.1
Minneapolis, Minn	21	0.70	3.8	2.8	1.4
New Orleans, La	22	0.69	7.0	4.7	1.5
Portland, Oreg	18	0.93	2.2	2.4	0.9
Washington, D. C	21	0.90	5.1	3.3	1.5

ington, D.C., Little Rock, Portland, Cheyenne, Anchorage, and Minneapolis. The results, for an average of twenty samples collected at the same site on the same days during the period January 1958 to December 1958, underwent a bivariate analysis for an evaluation of the correlation coefficient for each city, and the resulting linear regressions (lines of best fit) were plotted. Table 1 and figure 1 present the results of this statistical analysis. The statistical program devised for this study was such that a prediction of the RSN data can be obtained from NASN results by referring to the regression lines in figure 1.

The correlation coefficients for the data from these stations varied from 0.69 to 0.98 (average 0.86). Since it is assumed that the same air was sampled, the differences indicated must be the result of differences in sampling and laboratory procedures. Table 1 also presents the average gross beta concentrations for the samples taken at each individual station. Average surface air fission product gross beta concentrations for the NASN, on the same air samples varied from 0.9 to 2.2 times (average, 1.4) the RSN values.

A similar analysis was performed to determine the correlation coefficient for these two programs which operate sampling stations in the same urban area, but which have different sampling locations. A bivariate analysis was conducted for comparable samples from those cities. In this case, it was not assumed that the air samples obtained by these two programs were representative of the same air. Such a difference can result from differences

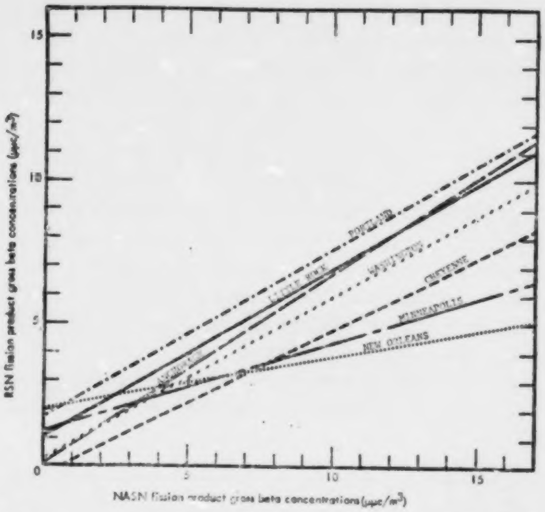

FIGURE 1.—STATISTICAL LINES OF BEST FIT (LINEAR REGRESSIONS), NASN AND RSN—SAME LOCATION

TABLE 2.—AVERAGE SURFACE AIR FISSION PRODUCT GROSS BETA CONCENTRATIONS (1958) AND CORRELATION COEFFICIENTS FOR THE NASN AND RSN AIR SAMPLES COLLECTED AT DIFFERENT LOCATIONS IN THE SAME CITIES

Station	Number of samples	Correlation coefficient (RSN-NASN)	NASN ($\mu\mu c/m^3$)	RSN ($\mu\mu c/m^3$)	Ratio $\left(\frac{NASN}{RSN}\right)$
Boise, Idaho	21	0.97	6.4	4.9	1.3
Denver, Colo	17	0.91	7.2	6.6	1.1
Honolulu, Hawaii	20	0.16	7.6	2.4	3.2
Phoenix, Ariz	17	0.95	14.1	8.4	1.7
Salt Lake City, Utah	21	0.44	7.9	8.6	0.9
Seattle, Wash	13	0.92	5.1	5.7	0.9

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in local meteorological conditions and in the elevation of the samplers. The cities concerned in this group are Seattle, Phoenix, Denver, Boise, Salt Lake City, and Honolulu. The results of this bivariate analysis are presented in table 2. Figure 2 illustrates the respective lines of regression (lines of best fit). NASN results are an average of 1.5 times greater than the RSN results.

With the exception of Salt Lake City and Honolulu, the correlation coefficients are in good agreement with those obtained from data on samples taken from cities in which the samplers were located at the same site. In these two exceptional cases, the low correlation coefficients show that factors other than sampling and laboratory procedures may be responsible to a greater degree for variations in the results obtained by these two programs. More specific information on the topography, weather conditions at the time each sample was taken, the elevation of the collector, and individual environmental variations at the Salt Lake City and Honolulu stations would be necessary to arrive at further conclusions as to what factors are of greatest significance in influencing the variations in results obtained from these two programs.

In conclusion, the surface air fission product gross beta concentrations reported by the NASN were, on the average, about 1.5 times those reported by the RSN. This difference in observed activities appears to be due primarily to sampling and counting techniques for the seven stations where the collectors stand side by side, and for four of the six stations where the samplers are in different locations in the same city. In the case of two stations (Salt Lake City and Honolulu) environmental factors such as differences in station location (meteorology and topography) play a greater role than at the other stations investigated.

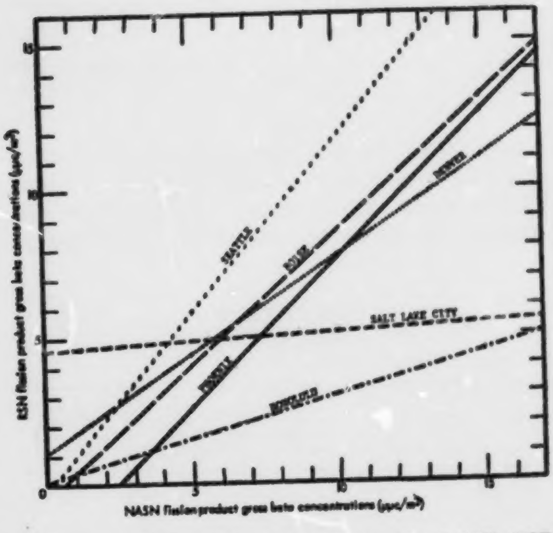

FIGURE 2.—STATISTICAL LINES OF BEST FIT (LINEAR REGRESSIONS), NASN AND RSN—DIFFERENT LOCATIONS

A Comparison of Data for Cincinnati Stations of NASN and RSN

The Sanitary Engineering Center is in the unique position of performing surface air fission product gross beta determinations for the National Air Sampling Network, and for the station in Cincinnati that had been reporting as a part of the Radiation Surveillance Network.

Sampling and laboratory techniques employed by the NASN are described in the first part of this discussion. A minor change in the counting procedure was instituted in June 1960. Since that time, the air filters are counted two days after the receipt of the filter, and there is no attempt to extrapolate back to the date of collection.

The sampling and laboratory techniques of the RSN station located in Cincinnati, differ appreciably from those employed by the NASN and those employed by the Central RSN laboratory in Washington, D.C. This variation has been introduced because this station conducts their own analyses for surface air fission product gross beta concentrations as well as for radon and thoron concentrations in the atmosphere. The radon and thoron data are discussed elsewhere (4).

The RSN sampler at Cincinnati, Ohio, consists of a self-lubricating vacuum pump with a sampling rate of 1 to 2 cfm. The volume of air filtered in a normal 24 hour sampling period is approximately 28 to 30 cubic meters. Air particulates are collected on a 47 mm diameter membrane filter whose pore size is 0.80 micron (4). Fission product gross beta concentrations are determined two days [1] after the end

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[1] Subsequently changed to four days.

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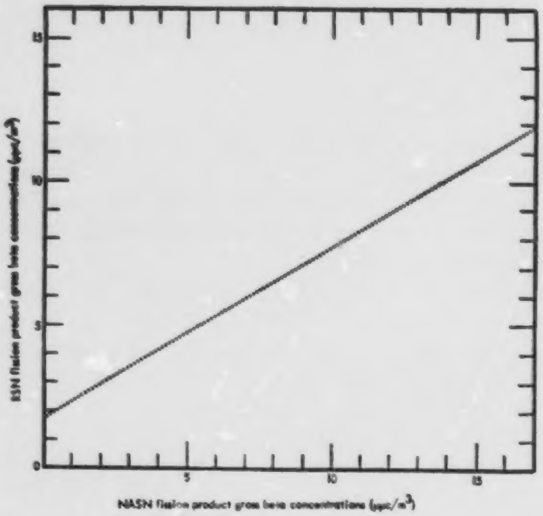

FIGURE 3.—STATISTICAL LINES OF BEST FIT (LINEAR REGRESSIONS), NASN AND RSN—CINCINNATI, OHIO

of the sampling period, and no extrapolation is made to the date of collection. The filters are placed on a 2″ diameter aluminum planchet and ashed. The gross beta activity is measured by placing the planchet in a 2″ diameter internal proportional counter (NMC–PC3A). The overall efficiency for samples with a negligible solids content is 55–75 percent (depending on the beta energies). A uranium oxide source is used as a secondary standard (*2*). The secondary source is covered with an aluminum foil to shield out the alpha activity.

The NASN sampler was located on the roof of the police station at 417 Lincoln Park Drive in 1958 and 1959, and on the roof of the nearby Cincinnati Public Library in 1960. The RSN station is located on the second floor of the Robert A. Taft Sanitary Engineering Center approximately four miles from the NASN sampler. Therefore, local climatological and topographical factors, as well as sampling and laboratory techniques, will influence the levels of radioactivity reported by the respective sampling programs.

The arithmetic mean for the NASN surface air fission product gross beta concentration for this period is 5.5 μμc/m³; the corresponding value for RSN results is 5.9 μμc/m³. The ratio of the mean NASN values to the RSN values is 0.9. The correlation coefficient (RSN–NASN) is 0.69. The corresponding statistical line of best fit (regression line) for the RSN versus NASN results is presented in figure 3.

The correlation coefficient obtained in this study is less than the average correlation coefficient for stations at which the samplers were at the same location, but still within the range of values reported for these stations. A comparison to those stations where the samplers were at different locations shows that the correlation coefficient for the Cincinnati data is lower than those at four of the six stations, but higher than the correlation coefficient for Salt Lake City and Honolulu.

In conclusion, laboratory and sampling techniques, as well as the sampler location, influence surface air fission product gross beta results. The degree to which these variables influence the results has not been determined by this study, nor has there been an attempt to define the effects of specific factors in the above variables which influence differences in such measurements.

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High Altitude Sampling Program

Defense Atomic Support Agency, Department of Defense

This is the first of a series of interpretive reports on the Department of Defense High Altitude Sampling Program (HASP). Without going into extensive detail this report will provide a broad outline of the scope of the program, the salient features and implications of the results obtained by the program, and the major conclusions to be drawn therefrom. Future reports in this series will highlight some of the specific facets of the program.

In this program, U-2 aircraft operated by the Strategic Air Command have collected particulate debris on filter papers (IPC–1478) which were especially developed to have both high porosity and high collection efficiency. (*1*) Radiochemical analyses of these samples has been performed at Isotopes Inc., Westwood, N.J. (*2–4*) Figure 1 shows the HASP network. In 1957, north-south sampling was established in the Northern Hemisphere. During 1958 operations were transferred to the Southern Hemisphere, and 1959 marked the termination of the active phase of HASP with major sampling resumed in the Northern Hemisphere. Continued semiannual spot checks are being made at 4 locations extending from Australia to Alaska.

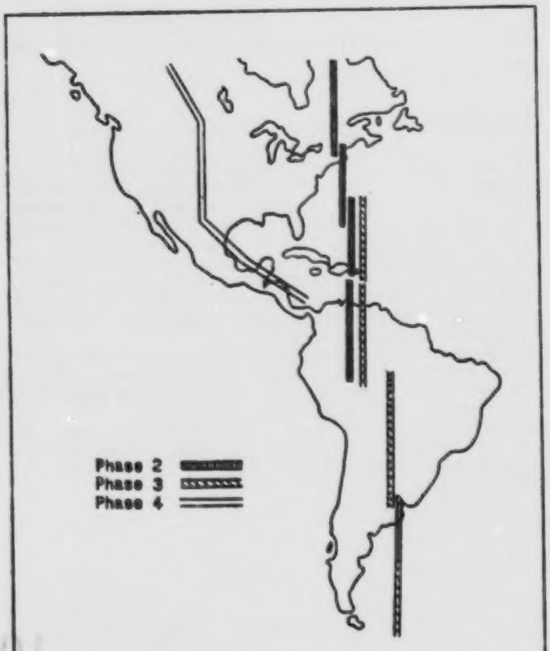

FIGURE 1.—HASP FLIGHT TRACKS

Since the stratospheric winds tend to blow either easterly or westerly, depending upon latitude and altitude, the north-south network allows representative samples to be taken. Since the U-2 has an operating range of up to 3600 miles and an altitude capability of 70,000 feet, over one-half of the stratosphere can be sampled. Extrapolation up to 100,000 feet has been made using samples collected by balloons. Since each aircraft is capable of collecting 10 samples on each flight, and 8 flights per week have been scheduled, each point in this extensive network can be visited at least twice a month. Over 4,000 samples were collected between August 1957 and May 1960. These samples afforded a unique opportunity to study in detail the mixing of radioactive debris within the stratosphere and the interchange of debris between the stratosphere and the troposphere.

A number of isotopes have been studied during the course of the HASP program, but the major emphasis has been placed on strontium-90. Reasons for selecting this isotope include: (a) its relatively great abundance in fission products, (b) its half-life of 28 years which is long compared to the meteorological processes it is used to trace, (c) its convenient radiochemical characteristics, and finally (d) the fact that strontium-90 is probably the greatest single source of an internal biological hazard in world-wide fallout.

Figure 2 shows the distribution of strontium-90 concentrations in a vertical cross-section of the atmosphere. The horizontal scale is latitude plotted on a sine scale from pole to pole. The vertical scale is representative of altitude. The dark lines show the mean location of the tropopause, or boundary line between the troposphere and the stratosphere. From a meteorological point of view, these two regions are quite different. The troposphere, or lower atmosphere, is relatively turbulent

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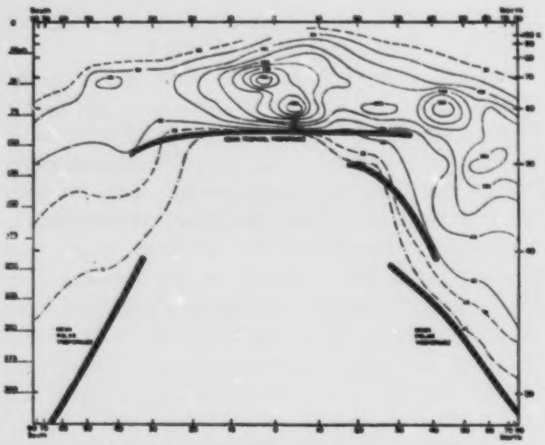

FIGURE 2.—MEAN STRONTIUM-90 DISTRIBUTION ($dpm/10^3SCF$) DURING NOVEMBER 1957–DECEMBER 1958

and is the region which contains all the "weather" phenomena. The stratosphere, on the other hand, is ordinarily relatively quiet and vertical mixing processes are inhibited. The boundary between the two regions, the tropopause, has discontinuities in the mid-latitude regions and is lower in the polar regions than in the tropics. The height of the tropopause is subject to seasonal as well as daily fluctuations, especially in the polar regions. While radioactivity in the troposphere is ordinarily washed out by rainfall within a few weeks, debris injected into the stratosphere may persist for years.

Since the time period shown in figure 2 marked a year of active weapons testing (1958), relatively steep concentration gradients are noted. The high concentrations in the lower equatorial region are due to US and UK testing, and the high concentrations in the lower northern stratosphere are the results of Soviet testing. An additional source of debris (not shown since it is well above the sampling range even of balloons) is from two high altitude, rocket-launched, megaton-range weapons which injected their debris into the very high atmosphere. Concentrations in the troposphere are low compared to the stratosphere since material entering this region is continually being removed by the scavenging action of rainfall.

Between 1958 and mid-1960, the situation changed in a rather marked manner because there were no large tests. The debris deposited in the lower stratosphere was gradually removed. Figure 3 shows the situation in early 1960. Notice there is now a minimum in the tropical region. The hot clouds in the northern polar region have also vanished. The highest concentrations are now found in the highest latitudes and at the highest altitudes. These high concentrations in part represent debris, initially injected into the high equatorial stratosphere by the 1958 rocket shots, which has moved poleward and then downward. During the polar winter night, the temperature structure of the stratosphere alters, and strong vertical mixing is promoted. High altitude debris is brought down during this time, and produces the distribution seen.

By adding up all the strontium-90 determinations derived by the HASP network, and using balloon data for extrapolation, the stratospheric burden during a selected time interval can be calculated (*5*). Table 1 provides a crude estimate of the inventories in the Northern and Southern Hemispheres during 1958, early and late 1959, and early 1960. The amounts injected above 100,000 feet have never been measured and, consequently, the estimates of concentrations in the highest region are somewhat conjectural. The values shown in parentheses are not measured values but educated guesses. Several features can be noted. The Northern Hemispheric stratosphere had more than twice as much strontium as that of the Southern Hemisphere in 1958, but by early 1960 its burden was only 50% greater. This tendency was caused by several factors. First, the Soviet debris in the Northern Hemisphere fell out

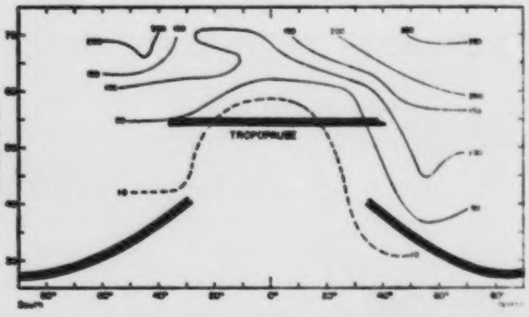

FIGURE 3.—STRATOSPHERIC DISTRIBUTION OF STRONTIUM-90 ($dpm/10^3SCF$) DURING JANUARY–JUNE 1960

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TABLE 1.—AVERAGE STRONTIUM-90 INVENTORIES
[Megacuries]

Northern Hemisphere

	1958	Early 1959	Late 1959	Early 1960
Highest Region	(.20)	(.20)	(.17)	(.13)
Balloon Region	.15	.27	.30	(.25)
HASP Region	.61	.38	.33	.37
Total	.96	.85	.80	.75

Southern Hemisphere

	1958	Early 1959	Late 1959	Early 1960
Highest Region	(.20)	(.19)	(.16)	(.12)
Balloon Region	.11	.15	(.17)	(.13)
HASP Region	.22	.13	(.16)	.27
Total	.53	.47	.49	.52

World Total

	1958	Early 1959	Late 1959	Early 1960
	1.49	1.32	1.29	1.27

quickly in early 1959. Second, there was probably some mixing southward across the equator.

In addition to shedding light on the amount of debris in the stratosphere, the HASP program has been able to delineate the rate of departure of this material from the stratosphere. The residence time of the debris is a function of the latitude and altitude of the injection. In addition, seasonally affected movements within the stratosphere influence the residence time. For instance, poleward mixing from the equatorial regions is faster during the winter, as is vertical mixing within the polar stratosphere (especially at the highest latitudes). Departure of debris from the stratosphere can be characterized fairly well by assigning half-residence times as follows: lower polar stratosphere, 6 months; lower equatorial and higher polar stratosphere, 1 year; higher equatorial stratosphere, 3 years; highest regions of the atmosphere, 6 years.

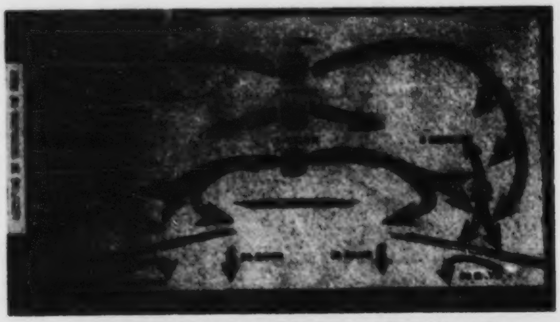

FIGURE 4.—HYPOTHETICAL MODEL OF STRATOSPHERIC MIXING AND TRANSFER

Debris injected into the tropical regions mixes poleward along surfaces that gradually slope downward. There is very little vertical mixing in the tropics and very little movement across the equatorial tropopause. Greater vertical mixing occurs in the polar stratosphere, especially in the vicinity of the tropopause gap which marks the location of the jet streams. Material injected into the top of the atmosphere is presumed to mix horizontally to a fairly uniform distribution within about 1 year and is then subject to downward mixing only in the polar regions during the winter night.

Movement into the troposphere may occur through the tropopausal gap and across the polar tropopause as it rises to a higher average elevation during the springtime. Since stratospheric processes increase the concentrations in the lower stratosphere during the winter, fallout on the ground is greatest during the spring (*6*), (*7*). Little interchange occurs during the autumn when the tropopause starts to lower and the gap shifts toward the equator. Since the debris departs from the stratosphere mainly in the temperate regions where there is a rainy belt (especially in springtime), the highest concentrations of fallout appear in the 30°–60° latitude band. In addition, vertical motion through the tropopause can bring down material. Any material brought across the tropopause at high latitudes mixes toward the Equator in the troposphere and also is scavenged by the mid-latitude rains.

In conclusion, it is seen that the HASP program has fairly well delineated the role that the stratosphere plays in the distribution of world-wide fallout. Total amounts in the stratosphere have been measured as well as their rates and locations of departure. As a result, a reconstruction of the past history of weapons testing can be made. Since the yield, location, and environment of past tests are fairly well known, as are the stratospheric injection rates and departure rates, we can plot the lower stratospheric inventory as a function of time. This is represented by the lower curve of Figure 5. Notice the two major peaks due to the high yield test series held in 1954 and 1958. For comparison, the "HASP inventories" are superimposed. These inventories are the sum of the

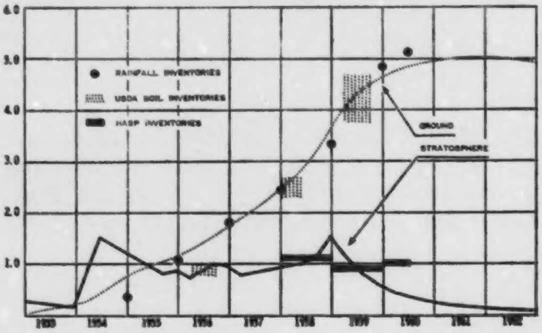

FIGURE 5.—STRONTIUM-90 INVENTORY

values shown in Table 1 for the HASP and Balloon regions. The apparent increase in the 1960 inventory is due to the influx of material from the high yield rocket shots of 1958 into the sampling regions. The upper curve shows the accumulation predicted in surface fallout from stratospheric debris from all the nuclear tests prior to 1959 (including material from the high yield rocket shots). Notice that the rate of fallout was greatest during the spring of 1959. Notice, too, that the peak concentration of strontium-90 on the ground has apparently been reached; that is, the rate of fallout is less than the rate of decay of the strontium-90 presently in the soil (2½% per year). Since concentrations of strontium-90 in food have tended to follow the rate of fallout more closely than the total amounts in the soil, the peak concentrations in food occurred over a year ago.

Soil and rainfall inventories measured by other programs confirm the prediction of total inventory made by HASP to within 15 to 20% (*8*). In addition, many of the details of the surface collection programs compare well with those of HASP, and, as a result, a well integrated picture of the meteorological processes involved in world-wide fallout has emerged.

While the ecological and biological problems involved in evaluating the hazards from world-wide fallout introduce considerable uncertainty, the meteorological facts that are known provide fairly well-defined boundary conditions. Table 2 provides a basis of comparison of the hazard from fallout from past weapons tests (*9*). Essentially the basic yardstick for comparison of the hazard is that provided by the natural background radiation.

TABLE 2.—RADIATION EXPOSURE FROM NUCLEAR WEAPONS TESTS

[in millirem]

Whole body dose from:	1959 (1 yr)	1955–1985 (30 yr)	1955–2025 (70 yr)
Internal C^{14}	0.4	5	8
Internal Cs^{137}	2	20	30
External Cs^{137}	1	20	30
External Zr, Ru, Ce	20	30	30
Total	23	75	98
Natural Background (cosmic rays, rocks, etc.)	100	3,000	7,000
Additional bone dose to children from:			
Internal Sr^{90}	7	75	103
Population RPG for Sr^{90}	170	5,000	12,000

It is seen that whole body irradiation comes from an internal exposure of cesium-137 and, to a lesser extent, carbon-14, as well as an external exposure from cesium-137 and shorter lived radioisotopes. During the period of greatest weapon testing, the dose level can rise to 20% of background. However, in the absence of future atmospheric testing, the 30-year genetically-significant dose will be no more than a small percent of background.

Strontium-90 provides the single greatest source of concentrated long-term exposure to a particular organ of the body, namely the skeleton. It can be seen that the lifetime dose from this source when added to the whole body dose (to which, of course, the bones are exposed) is still only a small percent of the natural background expected during the same period.

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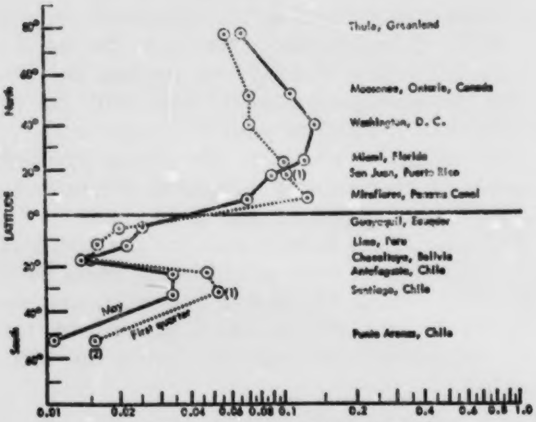
Radioactivity Measurements in Air

U.S. Naval Research Laboratory

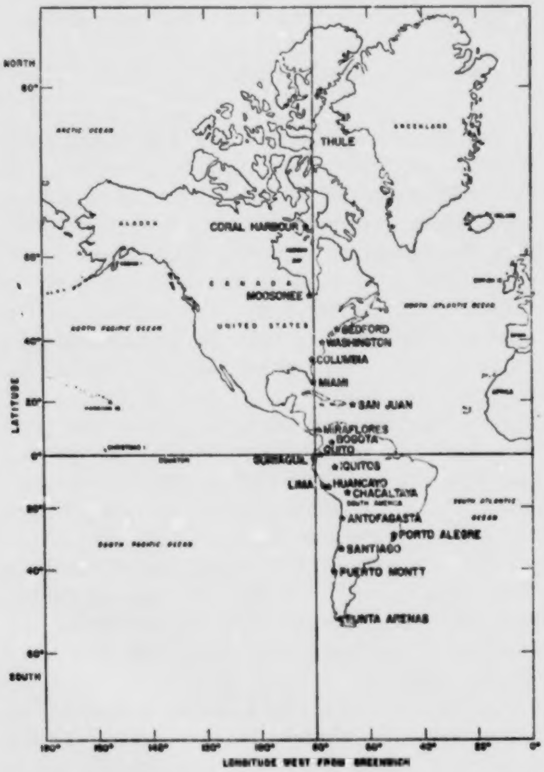
Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during May 1961 is presented in table 1, and the radioactivity profiles for the same month and the first quarter 1961 are shown in figure 1. This figure illustrates the data plotted in semilogarithmic coordinates. The abscissa is expressed in micromicrocuries per cubic meter of surface air. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).



(1) Average based on one month.
(2) Average based on two months.

FIGURE 1.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), FIRST QUARTER AND MAY 1961



NORTH
SOUTH
LATITUDE
80°
60°
40°
20°
0°
20°
40°
60°
ARCTIC OCEAN
GREENLAND
THULE
ALASKA
CORAL HARBOUR
CANADA
MOOSONEE
NORTH PACIFIC OCEAN
UNITED STATES
NORTH ATLANTIC OCEAN
BEDFORD
WASHINGTON
COLUMBIA
MIAMI
SAN JUAN
MIRAFLORES
BOGOTA
QUITO
EQUATOR
GUAYAQUIL
IQUITOS
LIMA
HUANCAYO
CHACALTAYA
SOUTH AMERICA
SOUTH ATLANTIC OCEAN
ANTOFAGASTA
PORTO ALEGRE
SOUTH PACIFIC OCEAN
SANTIAGO
PUERTO MONTT
PUNTA ARENAS
180°
160°
140°
120°
100°
80°
60°
40°
20°
0°
LONGITUDE WEST FROM GREENWICH

FIGURE 2.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (FROM NRL REPORT 5359, SEPT. 1959)

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TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION, MAY 1961

[Disintegrations per minute/cubic meter]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal	San Juan, Puerto Rico	Mauna Loa, Hawaii	Miami, Florida	Washington, D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1	0.02	----------	0.03	0.10	0.05	0.04	0.05	0.11	0.21	0.12	0.48	0.28	----------	0.23
2	0.01	----------	0.09	0.08	0.05	0.05	0.04	0.12	0.30	0.10	0.33	0.33	0.18	0.14
3	0.01	----------	0.09	0.08	0.05	0.05	0.04	0.12	0.30	0.10	0.33	0.33	0.18	0.14
4	0.04	----------	0.18	0.06	0.04	0.05	0.04	0.25	0.22	0.14	0.21	0.18	0.18	0.13
5	0.04	----------	0.07	0.06	0.04	0.05	0.04	0.25	0.22	0.14	0.21	0.18	0.26	0.13
6	0.02	----------	0.07	0.10	0.03	0.02	0.03	0.19	0.19	0.26	0.32	0.28	0.41	0.21
7	0.02	----------	0.07	0.10	0.03	0.02	0.03	0.19	0.19	0.26	0.32	0.28	0.41	0.21
8	0.02	----------	0.07	0.07	0.03	0.02	0.03	0.19	0.19	0.26	0.32	0.28	0.41	0.21
9	----------	----------	0.07	0.07	0.03	0.02	0.04	0.19	0.11	0.31	0.29	0.22	0.27	0.19
10	----------	----------	0.07	0.07	0.03	0.02	0.04	0.19	0.11	0.31	0.29	0.22	0.27	0.19
11	----------	----------	0.02	0.08	0.02	0.05	0.04	0.15	0.22	0.30	0.36	0.14	0.34	0.16
12	----------	----------	0.02	0.08	0.02	0.05	0.04	0.15	0.22	0.30	0.36	0.14	0.34	0.16
13	----------	----------	0.10	0.10	0.02	0.07	0.01	0.13	0.20	0.13	0.29	0.11	0.15	0.17
14	----------	----------	0.10	0.10	0.02	0.07	0.01	0.13	0.20	0.13	0.29	0.11	0.15	0.17
15	----------	----------	0.10	0.10	0.02	0.07	0.01	0.13	0.20	0.13	0.29	0.11	0.15	0.17
16	----------	----------	0.05	0.12	0.02	0.09	----------	0.14	0.21	0.14	0.37	0.31	0.19	0.14
17	----------	----------	0.05	0.12	0.02	0.09	----------	0.14	0.21	0.14	0.37	0.31	0.19	0.14
18	----------	----------	0.05	0.02	0.02	0.04	----------	0.16	0.19	0.19	0.42	0.52	0.31	0.14
19	----------	----------	0.05	0.02	0.03	0.04	0.07	0.16	0.19	0.19	0.42	0.52	0.31	0.14
20	----------	----------	0.07	0.08	0.03	0.05	0.07	0.15	0.22	0.21	0.33	0.41	0.25	0.09
21	----------	----------	0.07	0.08	0.03	0.05	----------	0.15	0.22	0.21	0.33	0.41	0.25	0.09
22	----------	----------	0.07	0.08	0.03	0.05	----------	0.15	0.22	0.21	0.33	0.41	0.25	0.09
23	----------	----------	0.14	0.07	0.03	0.06	----------	0.17	0.20	0.22	0.31	0.31	0.18	0.13
24	----------	0.02	0.14	0.07	0.03	0.06	0.06	0.17	0.20	0.22	0.31	0.31	0.18	0.13
25	----------	0.02	0.09	0.08	0.03	0.05	0.06	0.09	0.20	0.33	0.13	0.63	0.18	0.12
26	----------	0.02	0.09	0.08	0.03	0.05	0.06	0.09	0.20	0.33	0.13	0.63	0.06	0.12
27	----------	0.05	0.07	0.06	0.04	0.03	----------	0.13	----------	0.26	0.13	0.24	0.21	0.13
28	----------	0.05	0.07	0.06	0.04	0.03	----------	0.13	----------	0.26	0.13	0.24	0.21	0.13
29	----------	0.05	0.07	0.06	0.04	0.03	----------	0.13	----------	0.26	0.16	0.24	0.21	0.13
30	----------	0.05	----------	0.08	0.05	0.07	----------	0.18	----------	0.12	0.20	0.51	0.30	0.11
31	----------	0.05	----------	0.08	0.05	0.07	----------	0.18	----------	0.12	0.20	0.51	0.30	0.11
Mean (dpm/m³)	0.022	0.039	0.077	0.078	0.032	0.049	0.040	0.155	0.205	0.206	0.289	0.313	0.243	0.147
Mean (μμc/m³)	0.010	0.018	0.035	0.035	0.014	0.022	0.018	0.070	0.092	0.093	0.130	0.141	0.109	0.066

National Air Sampling Network

Division of Air Pollution, Public Health Service

The Public Health Service developed its National Air Sampling Network in 1953 to secure basic data on the nature and extent of air pollution throughout the United States, and to detect trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

The current basic network consists of 103 sampling stations operating every year in 66 large cities and 37 nonurban areas. In addition to these every-year stations, 126 cities have stations which operate every other year. Thus, there are 229 sampling stations in all, of which about 166 are active in any given year. A list of National Air Sampling Network Stations appeared in the May 1960 issue of *Radiological Health Data.*

The network stations are manned by cooperating federal, state, and local agencies. Twenty-four hour samples of suspended particulate matter representing approximately 2000 cubic meters of air are collected on glass fiber filters on a bi-weekly random sampling schedule. The analyses of these samples include the measurement of total quantity of suspended particulate matter, the organic matter soluble in benzene, and gross beta radioactivity. Selected samples are analyzed also for nitrates and sulfates, and for a number of metals.

Quarterly reports of individual sample data and annual summaries are distributed to all participating agencies and state health departments. A comprehensive report on the first five years of operation of the Network is contained in the publication, *Air Pollution Measurements of the National Air Sampling Network,* Public Health Service Publication No. 637, 1958.

Gross beta activity, by states for the years 1953 through 1958 was submitted by Dr. F. J. Weber, Chief of the Division of Radiological Health, Public Health Service, in testimony before the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 173–185.

Previous data on gross beta activities of particulates in air were published in *Radiological Health Data,* Volume I, Numbers 7 and 8; and Volume II, Numbers 1, 4, and 7. Data for the second quarter 1961 are presented in table 1.

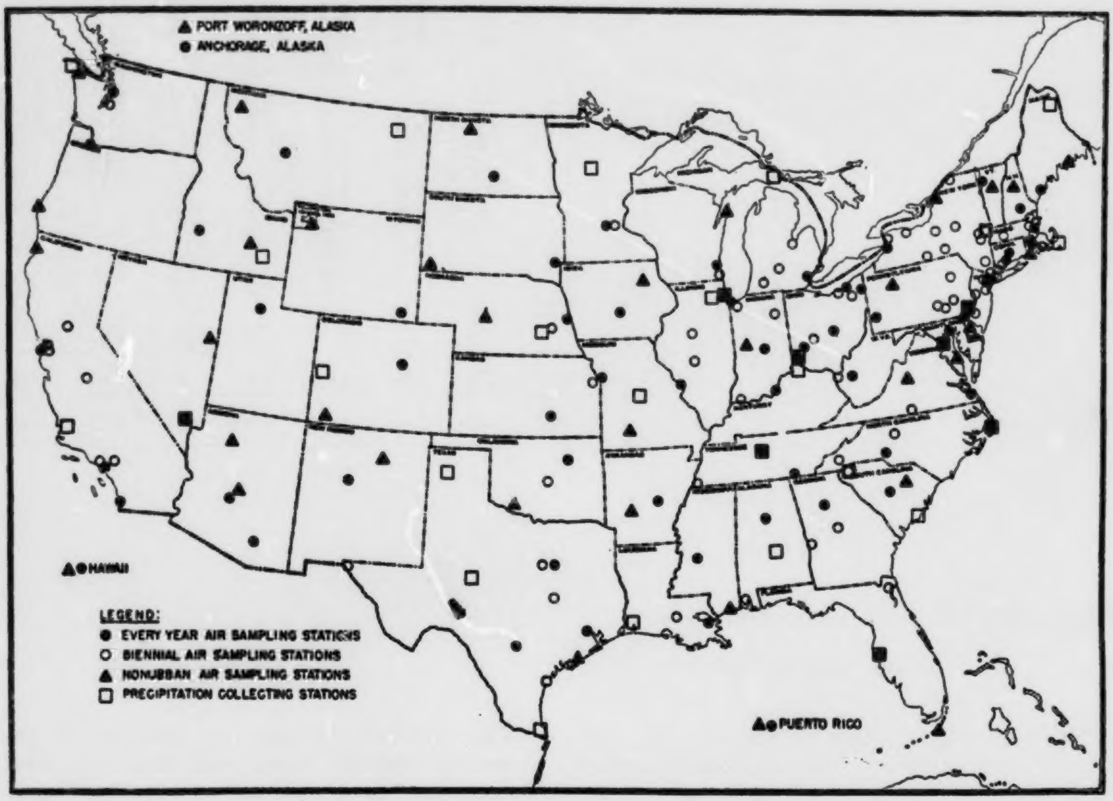
▲ PORT WORONZOFF, ALASKA
● ANCHORAGE, ALASKA
▲● HAWAII
▲● PUERTO RICO
LEGEND:
● EVERY YEAR AIR SAMPLING STATIONS
○ BIENNIAL AIR SAMPLING STATIONS
▲ NONURBAN AIR SAMPLING STATIONS
☐ PRECIPITATION COLLECTING STATIONS

FIGURE 1.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS

TABLE 1.—GROSS BETA RADIOACTIVITY IN AIR, SECOND QUARTER 1961

($\mu\mu c$ per cubic meter)

Station location	Number of samples	Minimum	Maximum	Average
Acadia Nat. Pk., Maine [1]	6	<0.1	0.6	0.2
Akron, Ohio	7	0.1	0.2	0.1
Albany, N. Y	6	<0.1	0.3	0.1
Albuquerque, N. M	5	0.1	0.1	0.1
Allentown, Pa	5	<0.1	0.2	0.1
Altoona, Pa	2	<0.1	0.1	0.1
Anchorage, Alaska	7	<0.1	0.2	<0.1
Atlanta, Ga	4	0.1	0.2	0.2
Atlantic City, N. J	6	0.1	0.2	0.1
Augusta, Ga	7	0.1	0.3	0.2
Austin, Tex	7	0.1	0.2	0.1
Baltimore, Md	7	0.1	0.6	0.2
Beaumont, Tex	6	0.1	0.2	0.1
Berkeley, Calif	7	<0.1	0.1	0.1
Bethlehem, Pa	7	0.1	0.1	0.1
Binghamton, N. J	7	0.1	0.2	0.1
Birmingham, Ala	6	0.1	0.2	0.2
Bismarck, N. D	7	0.1	0.3	0 1
Black Hills Frst., S. D.[1]	4	0.1	0.2	0.1
Boise, Idaho	6	0.1	0.4	0.2
Boston, Mass	6	<0.1	0.3	0.2
Brockton, Mass	7	<0.1	0.4	0.1
Burlington, Vt	5	0.1	0.3	0.1
Butte County, Idaho [1]	6	0.1	0.2	0.2
Calhoun County, Tex.[1]	3	0.1	0.3	0.2
Calvert County, Md.[1]	6	<0.1	0.2	0.1
Cambridge, Mass	4	0.1	0.2	0.2
Canton, Ohio	6	0.1	0.4	0.2

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Table 1.—GROSS BETA RADIOACTIVITY IN AIR, SECOND QUARTER 1961—Continued

[μμc per cubic meter]

Station location	Number of samples	Minimum	Maximum	Average	Station location	Number of samples	Minimum	Maximum	Average
Cape Hatteras, N. C.[1]	5	<0.1	0.4	0.1	Montezuma County, Col.[1]	7	0.1	0.5	0.2
Cape Vincent, N. Y.[1]	5	0.1	0.2	0.1	Mt. Vernon, N. Y	5	<0.1	0.2	0.1
Charlotte, N. C	6	0.1	0.3	0.2	Nashville, Tenn	6	0.1	0.3	0.2
Charleston, S. C	7	0.1	0.3	0.2	New Albany, Ind	6	0.1	0.3	0.1
Charleston, W. Va	6	0.1	0.3	0.2	New Bedford, Mass	6	<0.1	0.3	0.1
Chattanooga, Tenn	6	0.1	0.3	0.2	New Britain, Conn	6	<0.1	0.2	0.1
Cherokee County, Okla.[1]	6	<0.1	0.5	0.2	New Haven, Conn	7	0.1	0.4	0.2
Cheyenne, Wyo	6	0.1	0.3	0.2	New Orleans, La	6	0.1	0.3	0.2
Chicago, Ill	7	0.1	0.3	0.2	New Rochelle, N. Y	6	<0.1	0.2	0.1
Cincinnati, Ohio	6	<0.1	0.2	0.1	New York, N. Y	7	0.1	0.1	0.1
Clallum County, Wash.[1]	6	<0.1	0.1	<0.1	Newark, N. J	6	<0.1	0.2	0.1
Clarion County, Pa.[1]	5	<0.1	0.2	0.1	Niagara Falls, N. Y	5	0.1	0.5	0.2
Clayton County, Iowa[1]	3	0.1	0.2	0.2	Norfolk, Va	6	<0.1	0.2	0.1
Cleveland, Ohio	6	0.1	0.5	0.2	Oakland, Calif	4	0.1	0.1	0.1
Colfax County, N. Mex.[1]	7	0.1	0.4	0.2	Oklahoma City, Okla	7	0.1	0.4	0.2
Columbia, S. C	6	<0.1	0.3	0.2	Omaha, Nebr	6	0.1	0.5	0.2
Columbus, Ohio	6	0.1	0.4	0.2	Orange County, Vt.[1]	6	<0.1	0.5	0.2
Coos County, N. H.[1]	5	<0.1	0.4	0.1	Orlando, Fla	4	<0.1	0.3	0.2
Curry County, Oreg.[1]	4	<0.1	0.1	0.1	Paterson, N. J	4	<0.1	0.3	0.2
Dallas, Tex	7	0.1	0.3	0.2	Philadelphia, Pa	6	<0.1	0.4	0.2
Davenport, Iowa	6	0.1	0.3	0.2	Phoenix, Ariz	6	0.1	0.5	0.2
Dayton, Ohio	6	0.1	0.3	0.2	Pittsburgh, Pa	6	0.1	0.7	0.2
Dearborn, Mich	4	0.1	0.2	0.1	Portland, Maine	7	<0.1	0.2	0.1
Denver, Col	5	0.1	0.2	0.2	Portland, Oreg	6	<0.1	0.4	0.2
Des Moines, Iowa	6	0.1	0.2	0.2	Portsmouth, Va	6	<0.1	0.2	0.1
Detroit, Mich	7	0.1	0.2	0.1	Providence, R. I	6	<0.1	0.3	0.1
Door County, Wis.[1]	4	0.1	0.3	0.2	Pt. Woronzof, Alaska[1]	4	<0.1	0.2	0.1
Duluth, Minn	7	0.1	0.2	0.1	Raleigh, N. C	5	<0.1	0.2	0.1
East Chicago, Ind	8	<0.1	0.2	0.1	Richland County, S. C.[1]	7	0.1	0.5	0.2
East St. Louis, Ill	6	0.1	0.3	0.1	Richmond, Va	5	<0.1	0.1	0.1
Elmira, N. Y	7	<0.1	0.2	0.1	Roanoke, Va	7	<0.1	0.3	0.1
Erie, Pa	6	0.1	0.3	0.1	Rochester, N. Y	7	0.1	0.2	0.1
Eugene, Oreg	6	<0.1	0.2	0.1	Rockford, Ill	6	<0.1	0.3	0.2
Flint, Mich	7	0.1	0.3	0.2	Salt Lake City, Utah	4	0.1	0.2	0.2
Galveston, Tex	7	<0.1	0.2	0.1	San Antonio, Tex	5	0.1	0.3	0.2
Glacier Nat Pk., Mont.[1]	7	0.1	0.5	0.2	San Bernardino, Calif	6	0.1	0.4	0.2
Glen Cove, N. Y	6	0.1	0.2	0.1	San Diego, Calif	6	0.1	0.7	0.3
Glendale, Calif	5	<0.1	0.2	0.1	San Francisco, Calif	7	<0.1	0.3	0.1
Grand Canyon Pk., Ariz.[1]	5	0.1	0.3	0.2	San Jose, Calif	7	<0.1	0.1	0.1
Greensboro, N. C	6	0.1	0.1	0.1	San Juan, P. R	7	<0.1	0.1	0.1
Hammond, Ind	6	0.1	0.4	0.2	Savannah, Ga	6	<0.1	0.5	0.2
Hampton, Va	6	<0.1	0.2	0.1	Schenectady, N. Y	6	0.1	0.2	0.2
Hamilton, Ohio	7	0.1	0.2	0.1	Scranton, Pa	6	<0.1	0.3	0.1
Hartford, Conn	5	<0.1	0.2	0.1	Seattle, Wash	8	<0.1	0.4	0.1
Helena, Mont	6	0.1	0.5	0.2	Shannon County, Mo.[1]	5	0.1	0.2	0.2
Honolulu, Hawaii	7	<0.1	0.2	0.1	Shenandoah Nat. Pk., Va.[1]	6	0.1	0.2	0.1
Houston, Tex	7	0.1	0.2	0.1	Shreveport, La	4	<0.1	0.2	0.1
Humboldt County, Calif.[1]	6	<0.1	0.1	<0.1	Sioux Falls, S. D	6	0.1	0.5	0.2
Indianapolis, Ind	6	0.1	0.3	0.2	South Bend, Ind	5	0.1	0.5	0.2
Jackson County, Miss.[1]	3	0.1	0.1	0.1	Spokane, Wash	6	0.1	0.5	0.2
Jackson, Mich	7	0.1	0.2	0.1	St. Louis, Mo	6	0.1	0.4	0.2
Jackson, Miss	3	0.1	0.4	0.2	St. Paul, Minn	6	<0.1	0.3	0.1
Jersey City, N. J	5	<0.1	0.1	0.1	St. Petersburg, Fla	7	0.1	0.3	0.2
Johnstown, Pa	7	0.1	0.3	0.2	Stockton, Calif	5	0.1	0.1	0.1
Kahaluu, Hawaii[1]	6	<0.1	0.3	0.1	Syracuse, N. Y	6	<0.1	0.1	0.1
Kansas City, Mo	6	0.1	0.2	0.1	Tampa, Fla	6	<0.1	0.5	0.2
Kent County, Del.[1]	6	<0.1	0.5	0.2	Terre Haute, Ind	5	0.1	0.4	0.2
Knoxville, Tenn	6	0.1	0.4	0.3	Thomas County, Nebr.[1]	7	0.1	0.4	0.2
Las Vegas, Nev	4	0.1	0.4	0.3	Toledo, Ohio	6	<0.1	0.3	0.1
Little Rock, Ark	6	0.1	0.2	0.1	Topeka, Kans	6	0.1	0.5	0.2
Long Beach, Calif	6	0.1	0.1	0.1	Troy, N. Y	6	<0.1	0.2	0.1
Loquillo Mtns., P. R.[1]	7	<0.1	0.4	0.1	Tulsa, Okla	4	<0.1	0.5	0.3
Los Angeles, Calif	6	0.1	0.4	0.2	Tucson, Ariz	7	0.1	0.5	0.2
Louisville, Ky	5	0.1	0.2	0.1	Utica, N. Y	7	<0.1	0.4	0.2
Lowell, Mass	6	<0.1	0.2	0.1	Ward County, N. D.[1]	7	<0.1	0.3	0.1
Madison, Wis	6	0.1	0.3	0.2	Washington County, R. I.[1]	6	<0.1	0.3	0.2
Manchester, N. H	5	<0.1	0.3	0.1	Washington, D. C	7	0.1	0.4	0.2
Maricopa County, Ariz.[1]	7	0.1	0.5	0.3	Waterbury, Conn	5	<0.1	0.2	0.1
Massena, N. Y	5	0.1	0.3	0.2	Wheeling, W. Va	2	0.1	0.1	0.1
Medford, Oreg	5	0.1	0.2	0.1	White Pine County, Nev.[1]	6	0.1	0.5	0.2
Memphis, Tenn	6	<0.1	0.3	0.1	Wichita, Kans	4	0.1	0.3	0.2
Miami, Fla	6	<0.1	0.3	0.1	Wilmington, Del	6	0.1	0.2	0.2
Milwaukee, Wis	5	<0.1	0.2	0.1	Worcester, Mass	3	<0.1	0.1	0.1
Minneapolis, Minn	7	0.1	0.2	0.1	Yellowstone Pk., Wyo.[1]	6	0.1	0.5	0.2
Montgomery, Ala	6	0.1	0.2	0.1	York, Pa	6	0.1	0.5	0.2
Montgomery County, Ark.[1]	5	<0.1	0.3	0.1	Youngstown, Ohio	6	<0.1	0.2	<0.1
Montgomery County, Ind.[1]	5	0.1	0.6	0.2					

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[1] Nonurban station.

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Gross Beta Radioactivity in Precipitation

Precipitation Collection Section, National Air Sampling Network
Division of Air Pollution, Public Health Service

During 1959 a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. The collection stations are located at Weather Bureau offices or airport stations. Monthly composite samples of precipitation are collected at 30 stations and forwarded to the Network laboratory for analysis. A list of these precipitation collection stations is given below. Samples are analyzed for total solids and a large number of metals and nonmetals. In addition, samples representing 85 percent or more of the official rainfall recorded at the collecting stations are analyzed for fission product gross beta radioactivity if a large enough volume remains after the requirements for the chemical analysis have been met.

PRECIPITATION COLLECTION STATIONS

National Air Sampling Network

Alabama: Montgomery
California: Santa Maria
Colorado: Grand Junction
Florida: Tampa
Idaho: Pocatello
Illinois:
  Chicago (Midway Airport)
  Chicago (O'Hare Airport)
Louisiana: Lake Charles
Maine: Caribou
Maryland: Silver Hill
Massachusetts: Nantucket
Michigan: Saulte Ste. Marie
Minnesota: St. Cloud
Missouri: Columbia
Montana: Glasgow
Nebraska: Grand Island
Nevada: Las Vegas
New York: Albany
North Carolina: Cape Hatteras
Ohio:
  Cincinnati (research station)
  Cincinnati (airport)
Pennsylvania: Philadelphia
South Carolina:
  Charleston
  Greenville
Tennessee: Nashville
Texas:
  Brownsville
  San Angelo
  Amarillo
Virginia: Sterling
Washington: Tatoosh Island

TABLE 1.—GROSS BETA RADIOACTIVITY OF PRECIPITATION, SECOND QUARTER, 1961

Station	April		May		June	
	µµc/liter	µµc/m²	µµc/liter	µµc/m²	µµc/liter	µµc/m²
Albany, N. Y.	24	1,700	23	2,900	(a)	(a)
Amarillo, Tex.	(a)	(a)	16	1,400	(a)	(a)
Cape Hatteras, N. C.	12	900	12	1,200	9	900
Caribou, Maine	12	1,100	(a)	(a)	41	2,100
Charleston, S. C.	(a)	(a)	(a)	(a)	11	1,600
Chicago, Ill. (Midway)	(a)	(a)	(a)	(a)	39	3,200
(O'Hare)	(a)	(a)	(a)	(a)	25	2,400
Cincinnati, Ohio (Airport)	22	1,500	15	2,600	(a)	(a)
Columbia, Mo.	20	2,300	20	3,100	21	2,000
Grand Island, Nebr.	(a)	(a)	(a)	(a)	26	2,400
Grand Junction, Colo.	(a)	(a)	19	3,300	(a)	(a)
Greenville, S. C.	14	1,500	35	2,100	20	2,000
Lake Charles, La.	(a)	(a)	(a)	(a)	6	500
Montgomery, Ala.	(a)	(a)	(a)	(a)	8	800
Nantucket, Mass.	26	3,500	11	1,600	(a)	(a)
Nashville, Tenn.	(a)	(a)	15	1,900	(a)	(a)
Philadelphia, Pa.	(a)	(a)	(a)	(a)	33	1,900
San Angelo, Tex.	(a)	(a)	13	800	4	500
Sault St. Marie, Mich.	(a)	(a)	(a)	(a)	19	2,500
St. Cloud, Minn.	(a)	(a)	20	1,200	(a)	(a)
Sterling, Va.	(a)	(a)	(a)	(a)	12	1,000

[a] No data available due to low collection efficiency or inadequate sample.

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SECTION II. — FOOD OTHER THAN MILK

Tri-City Diet Study

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

The Health and Safety Laboratory is continuing its dietary survey begun in March 1960 of the strontium-90 content of average diets of individuals living in New York City, San Francisco, and Chicago. The results obtained for these cities in the first and second set of samples were reported in HASL–90 (*1*) and HASL–111 (*2*) and presented in *Radiological Health Data*, Volume II, Numbers 4 and 6.

Selected foods, representing 19 food categories, are purchased at each of these three cities about every three months and are analyzed for strontium-90 and stable calcium. Using data from the U.S. Department of Agriculture, "Household Food Survey of 1955," the annual consumption by an individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 and calcium can then be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general. Hence, in the tables that follow, the values shown for food consumption may not be directly related to the original data in the source document.

The first two sets of results showed some variability in the calcium content obtained from analysis of the individual food categories. However there is a relative constancy of the average annual intake of calcium due to its strong dependence on relatively constant calcium content of milk. Therefore the analysis of food categories for stable calcium were discontinued following the second sampling. The total intake of calcium is calculated to be 383 grams with a standard deviation of less than five percent and is used to determine the strontium to calcium ratio in the total diet. Using the totals given in table 1, the following average concentrations in μμc/gm Ca may be derived for the year: New York, 10.4; Chicago, 7.9; San Francisco, 3.6.

Results for the third sampling in 1960 are reported in table 1 (*3*). The San Francisco diet continues to be much lower in strontium-90 content than the diets in New York City or Chicago.

The strontium-90 to calcium ratios of an average New York City diet in 1958 and 1959, based on the limited data reported in HASL–90, are estimated to have been 12 and 17 strontium units, respectively. Since the fallout rate in 1959 is known to have been greater than that in 1958 or that in 1960, these data confirm what is already generally known, namely that the strontium-90 contamination of foods depends to some extent on the fallout rate.

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Table 1.—STRONTIUM-90 LEVELS OF DIET—THIRD SAMPLING

Food type	Annual consumption (kg/yr)	New York City (October 1960)		Chicago (November 1960)		San Francisco (January 1961)	
		μμc/kg	μμc/yr	μμc/kg	μμc/yr	μμc/kg	μμc/yr
Whole grain products	11	17	187	15.3	168	1.5	16
Refined grain products	37	5.7	211	5.0	185	3.9	144
Refined grain flour	43	5.0	215	5.5	237	2.0	86
Milk, liquid	221	6.2	1370	6.3	1392	1.8	398
Potatoes	45	5.5	248	1.3	58	3.7	166
Macaroni	3	7.1	21	5.0	15	2.9	9
Beans, dried	3	8.4	25	15.7	48	4.2	13
Vegetables, canned	20	5.3	106	5.8	116	1.2	24
Vegetables, fresh	43	17.6	757	6.3	271	2.0	86
Vegetables, root	17	4.8	82	3.0	51	2.8	48
Fruit, canned	26	1.3	34	1.1	29	3.5	91
Fruit juices	19	3.2	61	3.0	57	2.6	49
Fruit, fresh	68	7.9	537	4.1	279	1.8	122
Rice	3	2.2	7	0.9	3	1.7	5
Eggs	16	3.2	51	1.4	22	2.3	37
Fish, fresh	8	0.1	1	2.6	21	0.4	3
Fish, shell	1	1.2	1	0.5	1	0.3	1
Meat	73	0.9	66	0.6	44	0.6	44
Poultry	17	0.8	14	0.9	15	2.1	36
Total annual intake			3992		3012		1378

Table 2.—ANNUAL STRONTIUM-90 INTAKE IN VARIOUS FOOD CATEGORIES

[Estimated percent of total]

Food types	New York City			Chicago			San Francisco		
	March 1960	June 1960	October 1960	May 1960	September 1960	November 1960	March 1960	August 1960	January 1961
Whole grain products	5.2	6.5	4.7	5.4	6.0	5.6	1.6	9.0	1.2
Refined grain products	8.6	7.9	5.3	11.9	11.3	6.2	4.7	12.4	10.4
Refined grain flour	10.2	8.3	5.4	11.9	11.4	8.0	7.8	12.7	6.2
Milk, liquid	48.0	51.1	34.3	33.1	41.4	46.2	46.2	31.1	28.9
Potatoes	10.1	3.0	6.2	3.2	4.2	1.9	9.9	2.0	12.0
Macaroni	0.5	0.3	0.5	0.7	0.8	0.5	0.5	0.9	0.7
Beans, dried	0.1	0.1	0.6	0.1	0.7	1.6	0.9	0.8	0.9
Vegetables, canned	1.9	1.2	2.7	2.3	3.6	3.9	1.8	1.2	1.7
Vegetables, fresh	5.4	12.3	19.0	11.6	7.9	9.1	4.9	9.6	6.2
Vegetables, root	2.1	1.8	2.1	2.8	1.9	1.7	4.9	0.9	3.5
Fruit, canned	0.9	1.0	0.9	1.2	0.8	1.0	1.8	3.6	6.6
Fruit juices	0.7	1.2	1.5	1.6	1.3	1.9	2.2	2.8	3.6
Fruit, fresh	0.5	2.7	13.5	10.0	3.6	9.4	2.3	5.0	8.9
Rice	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.4	0.4
Eggs	3.9	0.7	1.3	1.3	1.0	0.7	2.3	2.7	2.7
Fish, fresh	0.0	0.0	0.0	0.2	0.0	0.7	0.1	0.1	0.2
Fish, shell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat	1.7	1.4	1.7	1.8	2.4	1.5	6.9	2.7	3.2
Poultry	0.6	0.3	0.4	0.5	1.4	0.5	0.6	1.8	2.6
Total annual strontium-90 intake (μμc)	4376	4760	3992	4074	2991	3012	2007	1340	1378

Table 2 lists the percentage contribution of each food category to the total strontium-90 intake calculated for the year, at each city, for the three sampling periods. Data presented in this form make it possible to compare variations in the relative strontium-90 contribution of different dietary constituents with time, while minimizing the obscuring effect of geographic differences. The relative importance of milk as a strontium-90 source declined in New York City and San Francisco from the first half to the second half of 1960, but this effect was not seen in Chicago. Although the Tri-City Diet Study was not designed for this purpose, it will be of interest in future sampling to note which food categories are most sensitive to the fallout rate. The dependence of different food categories on fallout rate will not be readily discernible, because foods locally purchased may not have been locally or recently produced.

REFERENCES

(1) *Quarterly Summary Report, HASL-90,* August 18, 1960.

(2) *Quarterly Summary Report, HASL-111,* April 1, 1961.

(3) Data from *Quarterly Summary Report, HASL-113,* July 1, 1961.

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Radium-226 in Diet in Three U.S. Cities (*1*)

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The previous article entitled "Tri-City Diet Study," by Mr. J. Rivera, presented data concerning strontium-90 dietary concentrations in three cities, New York, Chicago, and San Francisco, for the program's third sampling period. Sampling has been conducted at approximately three month intervals.

In the process of determining strontium-89 and strontium-90 concentrations in these food samples, a purification step was introduced to remove any radium and barium present in the strontium fraction. This fraction has now been analyzed for Ra^{226}. Radium-226 concentrations were determined by the emanation of its gaseous daughter product, radon-222 from the radium-bearing fraction of the food samples collected since May 1960.

The food categories in table 1 are the same as those used to report previous strontium-90 data obtained in the Tri-City Diet Study (*2, 3*). These data are considered a preliminary summary, and a more detailed report will be published later.

REFERENCES

(*1*) Abstracted from report by same name in *Quarterly Summary Report*, HASL-113 (July 1, 1961).

(*2*) *Quarterly Summary Report*, HASL-105, Jan. 9, 1961 and *Radiological Health Data*, Vol. II, No. 4 (April 1961).

(*3*) *Quarterly Summary Report*, HASL-111, April 1, 1961 and *Radiological Health Data*, Vol. II, No. 6 (June 1961).

TABLE 1.—RADIUM-226 IN FOODSTUFFS

	New York City				Chicago				San Francisco			
	Survey No. 2 June 1960		Survey No. 3 October 1960		Survey No. 1 May 1960		Survey No. 2 September 1960		Survey No. 2 August 1960		Survey No. 3 January 1961	
	µµg/kg orig. mat'l	µµg intake per year	µµg/kg orig. mat'l	µµg intake per year	µµg/kg orig. mat'l	µµg intake per year	µµg/kg orig. mat'l	µµg intake per year	µµg/kg orig. mat'l	µµg intake per year	µµg/kg orig. mat'l	uug intake per year
Whole grain products	3.2	36	1.2	13	3.5	28	2.9	33	[b] 2.8	[b] 31	2.8	31
Refined grain products	3.2	118	1.5	54	3.3	123	2.0	76	2.9	106	2.5	94
Refined grain flour	2.7	117	1.7	74	2.4	106	2.0	84	1.34	58	0.83	36
Milk, liquid	0.25	56	0.24	84	0.24	53	0.22	49	0.22	49	0.20	44
Potatoes	2.0	90	2.5	113	1.4	64	0.77	35	[a] 1.0	[a] 46	2.0	91
Macaroni	2.1	6	1.8	5	1.6	5	1.9	6	1.2	4	1.7	5
Beans—dried	6.1	18	3.2	10	[a] 7.0	[a] 21	2.5	8	2.3	7	4.1	12
Vegetables, canned	2.2	44	0.54	11	1.8	37	1.1	22	0.91	18	1.0	20
Vegetables, fresh	2.4	105	1.2	53	2.2	97	0.57	25	0.66	28	0.84	36
Vegetables, root	3.4	57	2.3	39	[a] 2.0	[a] 34	1.8	31	[a] 2.6	[a] 44	2.4	40
Fruit, canned	0.37	10	0.37	10	1.2	31	0.26	7	0.50	13	0.73	19
Fruit juices	1.6	31	0.49	9	0.66	13	0.86	16	0.71	14	0.62	12
Fruit, fresh	1.5	99	2.8	192	1.4	92	0.57	30	0.91	62	0.65	44
Rice	1.5	5	1.0	3	0.70	2	0.37	1	0.63	2	0.80	2
Eggs	4.1	66	7.9	127	2.7	44	[b] 2.7	[b] 44	2.6	41	1.9	31
Fish, fresh	1.2	10	0.66	5	0.71	6	1.0	8	0.80	6	1.2	9
Fish, shell	1.2	1	1.1	1	2.5	3	1.7	2	2.0	2	1.0	1
Meat	0.44	32	0.47	34	0.45	32	0.64	47	0.80	59	0.55	40
Poultry	0.73	12	0.86	15	0.79	13	1.4	23	1.9	32	0 49	8
Total yearly consumption	----------	913	----------	822	----------	814	----------	556	----------	622	----------	575

[a] Data corrected by barium as well as strontium recovery.
[b] Sample missing. Paired values used for computing sums.

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SECTION III. — MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There are two Public Health Service Milk Monitoring Programs. The original network consisted of five milkshed sampling stations. It was later expanded to twelve stations, nine of which are still active. Raw milk is spot sampled at these stations. During 1960 a processed milk sampling program of 60 stations was established. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported separately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Alabama, and the Southwestern Radiological Health Laboratory at Las Vegas, Nevada, provide analytical services for the new program.

The objectives of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program more directly related to the milk consumed by the population was necessary. The Public Health Service, Department of Health, Education, and Welfare, acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of a comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors including laboratory methodology and collection methods. Until this study has been completed, and additional experience has been gained under the new program, no valid interpretation can be made of any differences of radioactivity in milk samples collected under the two systems.

Publication of the data from each program will normally follow about four months after sample collection because of the time required for shipment, processing, decay product buildup, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective of the project was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data*. For the period reported, one-gallon raw milk samples were collected from a dairy company once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. These samples represent between 2,000- and 90,000-gallon lots. The concentration of iodine-131, barium-140, and cesium-137 are currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the buildup of the strontium-90 daughter decay product, yttrium-90, over a two-week period. Measurements are made in a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter. The difference between the total strontium and strontium-90 is reported as strontium-89. Stable calcium is also determined.

The April through September 1960 issues of *Radiological Health Data* lists references for technical descriptions of analytical procedures.

Table 1 presents first quarter 1961 averages and the May 1961 data for the raw milk sampling stations.

Processed Milk Area Sampling Stations

The processed milk surveillance program will provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphasis of this expanded sampling and radioassay program are:

1. to measure the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. to provide one sampling point within each State with additional points when

TABLE 1.—RADIOACTIVITY IN MILK—RAW MILK SAMPLING STATIONS, FIRST QUARTER AND MAY 1961

[Radioactivity concentrations in $\mu\mu c$/liter]

Area	Calcium (gm/liter)		Strontium-90		Cesium-137	
	First quarter	May	First quarter	May	First quarter	May
Atlanta, Ga	1.18	1.16	13	14	25	20
Austin, Tex	1.16	1.15	7	2	15	<5
Chicago, Ill	1.17	1.13	6	8	20	25
Cincinnati, Ohio	1.21	1.17	8	11	15	15
New York, N. Y	1.11	1.15	9	9	20	15
Sacramento, Calif	1.19	1.14	5	4	10	15
Salt Lake City, Utah	1.19	1.16	4	3	10	10
Spokane, Wash	1.22	1.16	7	8	15	15
St. Louis, Mo	1.26	1.24	13	23	25	35
Network average	1.19	1.16	8	9	15	15

Note: I^{131}, Sr^{89} and Ba^{140} are below minimum detectable limits for samples collected in May. These limits are 10 $\mu\mu c$/liter for I^{131} and Ba^{140} and 5 $\mu\mu c$/liter for Sr^{89}.

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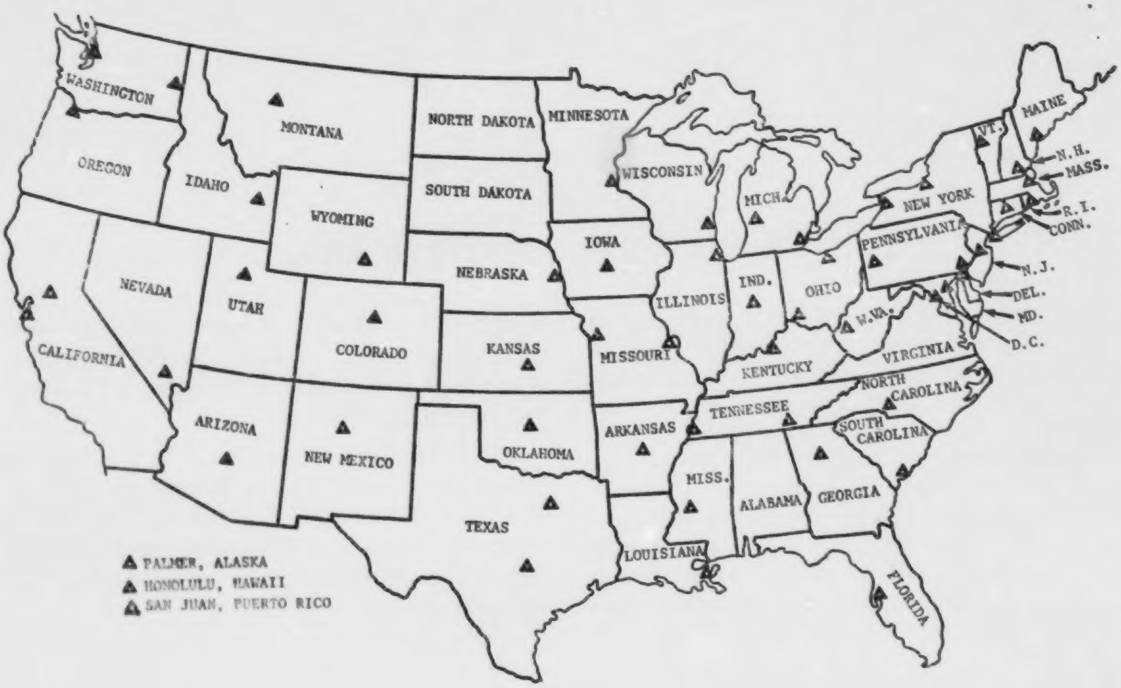
indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the western states. Figure 1 shows the locations of these stations.

At the present time, radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140} and I^{131} are being performed. For the period reported, the latter three radionuclides are not presently found in milk by the current methods of detection. The lower level of detection for Sr^{89} is 5 μμc/ liter, and for Ba^{140} and I^{131}, 10 μμc/liter. Other radionuclides of concern to public health agenies will be included for assay as necessary for a more complete monitoring of the milk supply.

Table 2 presents first quarter averages for 1961 and the May 1961 data for processed milk sampling stations.


WASHINGTON
OREGON
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NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICH.
IND.
OHIO
KENTUCKY
TENNESSEE
MISS.
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W.VA.
PENNSYLVANIA
NEW YORK
VT.
MAINE
N.H.
MASS.
R.I.
CONN.
N.J.
DEL.
MD.
D.C.
PALMER, ALASKA
HONOLULU, HAWAII
SAN JUAN, PUERTO RICO

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

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TABLE 2.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, FIRST QUARTER AND MAY 1961

[Radioactivity concentrations in μμc/liter]

Area	Calcium (gm/liter)		Strontium-90		Cesium-137	
	First quarter	May	First quarter	May	First quarter	May
Albuquerque, N. Mex	1.05	1.00	5	4	<5	<5
Atlanta, Ga	1.21	1.22	7	13	5	15
Austin, Tex	1.26	1.22	2	4	<5	5
Baltimore, Md	1.28	1.18	6	7	5	10
Boston, Mass	1.27	1.26	8	11	10	30
Buffalo, N. Y	[a] 1.18	1.19	[a] 6	10	[a] <5	20
Burlington, Vt	1.23	1.30	9	9	5	20
Charleston, S. C	1.35	1.27	8	14	5	20
Charleston, W. Va	1.21	1.16	5	10	<5	25
Charlotte, N. C	1.28	1.28	9	13	<5	15
Chattanooga, Tenn	1.33	1.34	8	10	<5	10
Chicago, Ill	[a] 1.16	1.18	[a] 6	6	[a] <5	15
Cincinnati, Ohio	1.24	1.21	7	10	<5	15
Cleveland, Ohio	1.21	1.20	6	9	<5	15
Dallas, Tex	1.29	1.24	5	9	<5	<5
Denver, Colo	1.03	1.04	6	5	5	<5
Des Moines, Iowa	1.07	1.00	7	6	<5	<5
Detroit, Mich	1.19	1.17	6	10	<5	15
Grand Rapids, Mich	1.24	1.26	7	7	<5	15
Hartford, Conn	1.19	1.16	7	8	10	25
Helena, Mont	1.04	0.97	4	6	<5	<5
Honolulu, Hawaii	1.05	0.90	4	6	<5	<5
Idaho Falls, Idaho	1.05	1.01	5	7	<5	<5
Indianapolis, Ind	1.26	1.21	7	8	<5	15
Jackson, Miss	1.37	1.34	10	14	<5	20
Kansas City, Mo	1.05	0.99	7	11	<5	5
Laramie, Wyo	1.06	1.02	5	4	<5	5
Las Vegas, Nev	1.03	1.01	3	2	<5	<5
Little Rock, Ark	1.27	1.18	13	22	5	30
Louisville, Ky	1.21	1.22	7	14	<5	15
Manchester, N. H	1.21	1.28	8	12	15	55
Memphis, Tenn	1.30	1.28	8	12	<5	<5
Milwaukee, Wis	1.23	1.15	5	5	<5	20
Minneapolis, Minn	1.00	1.01	7	5	<5	<5
New Orleans, La	1.31	1.31	8	15	10	20
New York, N. Y	[a] 1.18	1.25	[a] 7	10	[a] 5	30
Norfolk, Va	[a] 1.20	1.25	[a] 7	10	[a] <5	15
Oklahoma City, Okla	1.29	1.21	5	8	<5	<5
Omaha, Nebr	1.05	1.02	7	8	5	5
Palmer, Alaska	1.08	1.00	6	8	<5	<5
Philadelphia, Pa	1.27	1.16	7	8	<5	10
Phoenix, Ariz	1.09	0.98	2	5	<5	<5
Pittsburgh, Pa	1.24	1.22	9	12	<5	30
Portland, Me	[a] 1.20	1.28	[a] 10	9	[a] 10	40
Portland, Oreg	1.11	1.03	8	11	10	15
Providence, R. I	1.26	1.25	9	10	10	35
Sacramento, Calif	1.12	0.99	3	4	<5	<5
Salt Lake City, Utah	1.05	1.00	4	8	5	<5
San Francisco, Calif	1.05	1.02	3	5	<5	<5
San Juan, P. R	1.15	1.24	3	5	<5	<5
Seattle, Wash	1.09	1.04	7	9	10	15
Spokane, Wash	1.12	1.01	7	9	5	10
St. Louis, Mo	1.01	1.00	7	7	10	10
Syracuse, N. Y	1.22	1.23	6	8	<5	20
Tampa, Fla	1.26	1.22	5	4	35	110
Trenton, N. J	1.24	1.16	7	8	<5	<5
Washington, D. C	1.23	1.19	6	8	<5	30
Wichita, Kans	1.05	0.98	5	7	<5	10
Wilmington, Del	1.22	1.22	7	12	<5	5
Average	1.18	1.15	6	9	<5	15

[a] Average based on two months samples.

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SAMPLING PROGRAMS FOR RADIOACTIVITY IN MILK

The following article is one of a number of discussions concerned with concentrations of radionuclides in milk. This article summarizes data on strontium-90 concentrations in U.S. processed milk for the second quarter of 1960 through the first quarter of 1961. These data were compiled as part of the Public Health Service's Processed Milk Monitoring Program which is designed to document levels of specific radionuclides in milk consumed by the general population. The presentation and data were compiled by Messrs. Roscoe H. Goeke and Andreas P. Zizos of the Data Collation and Analysis Unit, Division of Radiological Health, Public Health Service.

The authors wish to express their appreciation to the Special Projects Branch, Division of Radiological Health, and to the Milk and Food Program, Division of Environmental Engineering and Food Protection, for supplying the basic information.

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Strontium-90 Concentrations In U.S. Processed Milk, Second Quarter 1960—First Quarter 1961

Milk Monitoring Program, Division of Radiological Health

Introduction

The Public Health Service Processed Milk Monitoring Program is designed to document levels of specific radionuclides in milk consumed by the general population. Approximately 60 processed milk area sampling stations have been established in cooperation with State and local health and milk sanitation agencies. This program began its operations in March 1960 in order to provide surveillance activities on a continuing basis. The following presentation is a statistical summary of strontium-90 concentrations in processed milk from April 1960 through March 1961 (only a limited number of samples were collected prior to April 1960).

In addition to strontium-90, analyses are conducted for stable calcium, cesium-137, strontium-89, barium-140 and iodine-131. The latter two radioisotopes have been below their minimum detection limits (10 μμc/liter). Strontium-89, with the exception of a small number of samples in March and April 1960, has also been below its minimum detection limit (5 μμc/liter). Cesium-137, strontium-90 and stable calcium concentrations were tabulated in *Radiological Health Data*, Volume II, Number 8. The minimum detectable concentration for strontium-90 is 1 μμc/liter, and its values are reported to the nearest whole number.

Milk is sampled throughout the United States by obtaining samples of pasteurized and homogenized milk at the processing plant. Procedures were developed to provide a sample of one day's sales per month in a community which would be as representative of the total supply as could be achieved under practical conditions. Each sample is a composite of plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

Once a month, one sample from each city is sent to either of the Public Health Service's Southwestern or Southeastern Radiological Health Laboratories located in Las Vegas, Nevada, and Montgomery, Alabama, respectively. The latter processes samples from 30 states generally east of the Mississippi, and the former, from the western states. Figure 2 illustrates the geographic distribution of the cities where processed milk is sampled, and table 1 shows their respective coordinates and elevations.

TABLE 1.—COORDINATES AND ELEVATIONS, PROCESSED MILK AREA SAMPLING STATIONS

Area	Latitude	Longitude	Ground elevation (feet)	Area	Latitude	Longitude	Ground elevation (feet)
Albuquerque, N. Mex	35° 03′ N	106° 37′ W	5310	Manchester, N. H	43° 00′ N	71° 28′ W	170
Atlanta, Ga	33° 39′ N	84° 25′ W	975	Memphis, Tenn	35° 03′ N	89° 59′ W	263
Austin, Tex	30° 18′ N	97° 42′ W	615	Milwaukee, Wis	42° 57′ N	87° 54′ W	672
Baltimore, Md	39° 17′ N	76° 37′ W	14	Minneapolis, Minn	44° 53′ N	93° 13′ W	830
Boston, Mass	42° 22′ N	71° 01′ W	15	New Orleans, La	29° 57′ N	90° 04′ W	[illegible]
Buffalo, N. Y	42° 56′ N	75° 44′ W	693	New York, N. Y	40° 47′ N	73° 58′ W	132
Burlington, Vt	44° 28′ N	73° 09′ W	331	Norfolk, Va	36° 53′ N	76° 12′ W	26
Charleston, S. C	32° 54′ N	80° 02′ W	41	Oklahoma City, Okla	35° 24′ N	97° 36′ W	1280
Charleston, W. Va	38° 22′ N	81° 36′ W	950	Omaha, Nebr	41° 18′ N	95° 54′ W	978
Charlotte, N. C	35° 13′ N	80° 56′ W	725	Palmer, Alaska	61° 36′ N	149° 05′ W	198
Chattanooga, Tenn	35° 02′ N	85° 12′ W	670	Philadelphia, Pa	39° 53′ N	75° 15′ W	7
Chicago, Ill	41° 47′ N	87° 45′ W	610	Phoenix, Ariz	33° 26′ N	112° 01′ W	1109
Cincinnati, Ohio	39° 09′ N	84° 31′ W	761	Pittsburgh, Pa	40° 30′ N	80° 13′ W	1151
Cleveland, Ohio	41° 24′ N	81° 51′ W	787	Portland, Maine	43° 39′ N	70° 19′ W	61
Dallas, Tex	32° 51′ N	96° 51′ W	476	Portland, Oreg	45° 32′ N	122° 40′ W	30
Denver, Colo	39° 46′ N	104° 53′ W	5292	Providence, R. I	41° 44′ N	71° 26′ W	55
Des Moines, Iowa	41° 32′ N	93° 39′ W	948	Sacramento, Calif	38° 35′ N	121° 29′ W	23
Detroit, Mich	42° 24′ N	83° 00′ W	619	Salt Lake City, Utah	40° 46′ N	111° 58′ W	4220
Grand Rapids, Mich	42° 54′ N	85° 40′ W	681	San Francisco, Calif	37° 47′ N	122° 25′ W	52
Hartford, Conn	41° 56′ N	72° 41′ W	169	San Juan, P. R	18° 28′ N	66° 07′ W	47
Helena, Mont	46° 36′ N	112° 00′ W	3893	Seattle, Wash	47° 36′ N	122° 20′ W	14
Honolulu, Hawaii	21° 19′ N	157° 52′ W	12	Spokane, Wash	47° 37′ N	117° 31′ W	2357
Idaho Falls, Idaho	43° 30′ N	112° 41′ W	4790	St. George, Utah	37° 06′ N	113° 34′ W	2700
Indianapolis, Ind	39° 44′ N	86° 16′ W	793	St. Louis, Mo	38° 45′ N	90° 23′ W	560
Jackson, Miss	32° 20′ N	90° 13′ W	305	Syracuse, N. Y	43° 07′ N	96° 07′ W	424
Kansas City, Mo	39° 07′ N	94° 35′ W	741	Tampa, Fla	27° 48′ N	82° 32′ W	19
Laramie, Wyo	41° 18′ N	105° 34′ W	7236	Trenton, N. J	40° 14′ N	74° 44′ W	56
Las Vegas, Nev	36° 05′ N	115° 10′ W	2162	Washington, D. C	38° 55′ N	77° 00′ W	14
Little Rock, Ark	34° 44′ N	92° 14′ W	257	Wichita, Kans	37° 39′ N	97° 25′ W	1321
Louisville, Ky	38° 11′ N	85° 44′ W	474	Wilmington, Del	39° 40′ N	75° 36′ W	78

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TABLE 2.—SUMMARY OF RESULTS, PROCESSED MILK AREA SAMPLING STATIONS, STRONTIUM-90 DETERMINATIONS[a]

(Average concentrations in μμc/liter)

Area	1960				1961
	First quarter	Second quarter	Third quarter	Fourth quarter	First quarter
Albuquerque, N. Mex	[b]3	5	4	4	5
Atlanta, Ga	--------	--------	[c]11	9	7
Austin, Tex	--------	[b]2	2	[c]2	2
Baltimore, Md	--------	--------	[c]7	8	6
Boston, Mass	--------	[b]16	12	10	8
Buffalo, N. Y	--------	6	7	6	[c]6
Burlington, Vt	--------	10	9	7	9
Charleston, S. C	--------	--------	[c]10	11	8
Charleston, W. Va	--------	9	10	8	5
Charlotte, N. C	--------	[b]14	12	11	9
Chattanooga, Tenn	--------	--------	[b]11	10	8
Chicago, Ill	--------	--------	7	5	[c]6
Cincinnati, Ohio	--------	--------	9	7	7
Cleveland, Ohio	--------	--------	8	7	6
Dallas, Tex	--------	[b]8	6	6	5
Denver, Colo	[b]8	8	5	7	6
Des Moines, Iowa	--------	[b]8	7	[c]8	7
Detroit, Mich	--------	--------	7	7	6
Grand Rapids, Mich	--------	--------	8	7	7
Hartford, Conn	--------	9	8	9	7
Helena, Mont	--------	[b]9	6	6	4
Honolulu, Hawaii	--------	3	6	4	4
Idaho Falls, Idaho	[b]4	7	5	5	5
Indianapolis, Ind	--------	--------	6	6	7
Jackson, Miss	--------	--------	[c]12	11	10
Kansas City, Mo	--------	8	7	8	7
Laramie, Wyo	--------	6	5	5	5
Las Vegas, Nev	[b]3	3	2	3	3
Little Rock, Ark	--------	--------	[c]13	[c]13	13
Louisville, Ky	--------	7	10	9	7
Manchester, N. H	--------	13	11	9	8
Memphis, Tenn	--------	--------	[b]14	9	8
Milwaukee, Wis	--------	--------	6	6	5
Minneapolis, Minn	--------	--------	[c]9	8	7
New Orleans, La	--------	--------	16	11	8
New York, N. Y	--------	[b]11	9	8	[c]7
Norfolk, Va	--------	--------	9	9	[c]7
Oklahoma City, Okla	--------	--------	8	7	5
Omaha, Neb	--------	--------	[c]8	6	7
Palmer, Alaska	[b]5	8	7	7	6
Philadelphia, Pa	--------	10	9	6	7
Phoenix, Ariz	--------	--------	4	4	2
Pittsburgh, Pa	--------	15	11	11	9
Portland, Maine	--------	[b]15	11	9	[c]10
Portland, Oreg	--------	11	10	9	8
Providence, R. I	--------	[b]18	11	9	9
Sacramento, Calif	--------	--------	[c]5	5	3
Salt Lake City, Utah	[b]8	7	4	5	4
San Francisco, Calif	--------	[b]8	3	4	3
San Juan, P. R	--------	--------	4	4	3
Seattle, Wash	--------	9	8	6	7
Spokane, Wash	--------	10	6	6	7
St. Louis, Mo	--------	--------	[c]7	8	7
Syracuse, N. Y	--------	7	7	7	6
Tampa, Fla	--------	--------	5	6	5
Trenton, N. J	--------	[b]10	7	8	7
Washington, D. C	--------	--------	8	8	6
Wichita, Kans	--------	7	6	5	5
Wilmington, Del	--------	[b]10	8	8	7

[a] Abstracted from *Radiological Health Data*, Volume II, Number 8.
[b] Average based on one month.
[c] Average based on two months.

Strontium-90 Concentrations in U.S. Milk; April 1960 Through March 1961

Table 2 presents the concentrations of strontium-90 in processed milk tabulated by quarters for each station. In all cases, the data were summarized as follows: In each calendar quarter (except for insufficient data during the first quarter of 1960), a mean was calculated for each station. The network and region means, standard deviations, and relative frequencies were calculated by weighing each station average by the number of samples. Histograms showing the distribution of strontium-90 concentrations in processed milk (μμc/liter) were then plotted. These calculations allow for comparisons of the data over relatively long periods of time which approximately correspond to the seasons of the year. The process of calculating quarterly network means and standard deviations from quarterly station averages would tend to make the data normally distributed in accordance with the "Central Limit Theorem." This last point may, or may not, be considered a disadvantage since it allows comparisons of the same type of distributions from one period of time to the next. In this manner, at least relative difference can be noted by simple statistical comparisons. Since there are no models which substantially justify the hypothesis that strontium-90 in processed milk follow some other type of distribution(s),

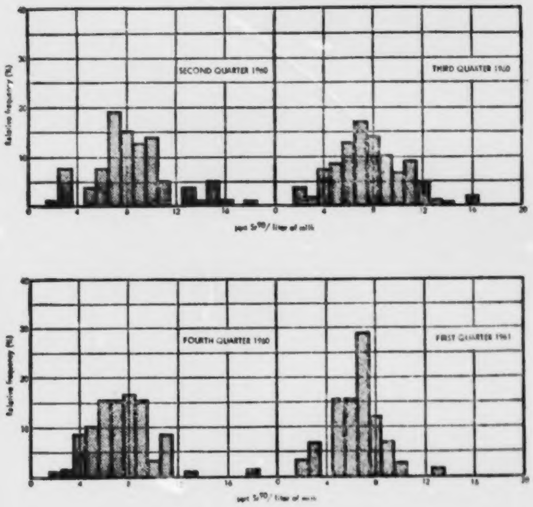


FIGURE 1.—FREQUENCY DISTRIBUTIONS OF STRONTIUM-90 IN U.S. PROCESSED MILK

TABLE 3.—TABULATION OF PERTINENT STATISTICS, STRONTIUM-90 IN U. S. PROCESSED MILK

Period	Number of stations	Number of samples	Mean (μμc/liter)	Standard deviation (μμc/liter)
Second quarter 1960	34	78	8	3
Third quarter 1960	59	164	8	3
Fourth quarter 1960	59	174	7	3
First quarter 1961	59	172	6	2

the method used here does not seem unreasonable. Table 3 presents the important statistics for each quarter. Figure 1 illustrates the distribution of strontium-90 concentrations in processed milk for the second quarter of 1960 through the first quarter of 1961.

A statistical comparison of these data by the use of a "t-test" at the 5 percent significance level reveals the relationships shown below. These relationships, based on the means, variances, significance level, and the number of samples, remain the same whether one assumes that the respective variances are equal or not (${}_2\mu_{60}$ denotes the mean for the second quarter of 1960, . . .).

$$
\begin{aligned}
{}_2\mu_{60} &= {}_3\mu_{60}\\
{}_2\mu_{60} &> {}_4\mu_{60}\\
{}_2\mu_{60} &> {}_1\mu_{61}\\
{}_3\mu_{60} &= {}_4\mu_{60}\\
{}_3\mu_{60} &> {}_1\mu_{61}\\
{}_4\mu_{60} &> {}_1\mu_{61}
\end{aligned}
$$

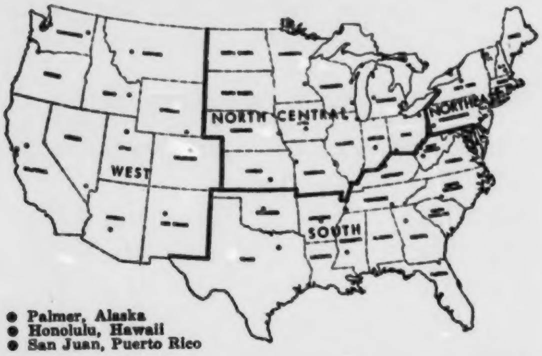


FIGURE 2.—REGIONS OF THE UNITED STATES WITH PROCESSED MILK AREA SAMPLING STATIONS

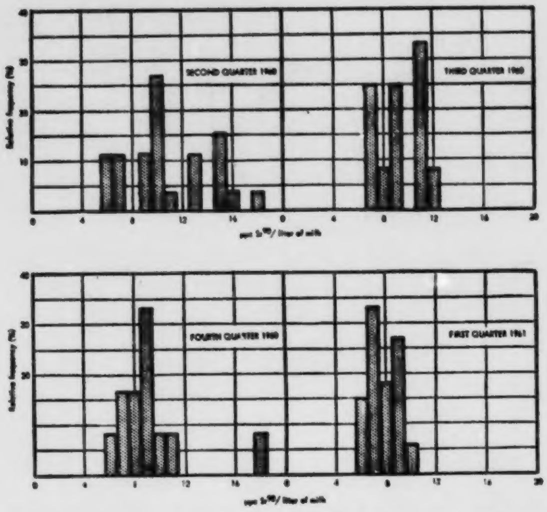


FIGURE 3.—NORTHEAST REGION—FREQUENCY DISTRIBUTIONS OF STRONTIUM-90 IN PROCESSED MILK

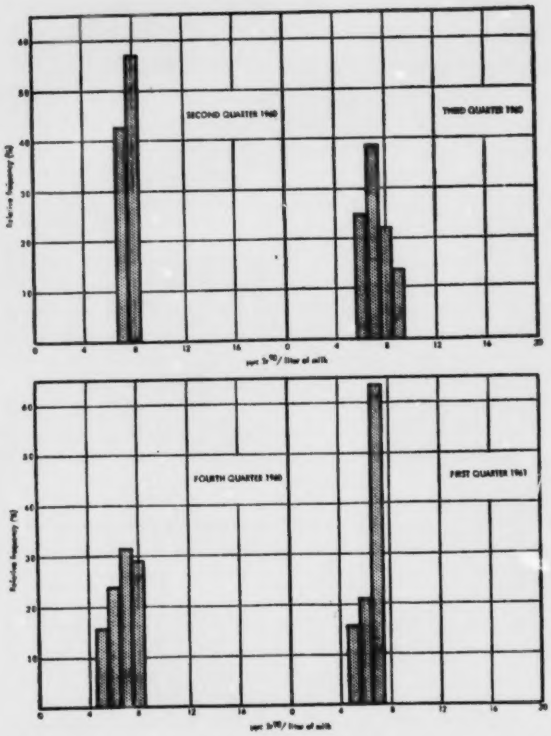


FIGURE 4.—NORTH CENTRAL REGION—FREQUENCY DISTRIBUTIONS OF STRONTIUM-90 IN PROCESSED MILK

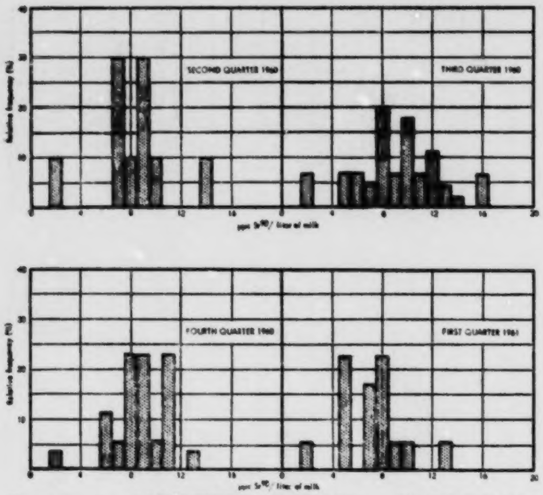


FIGURE 5.—SOUTHERN REGION — FREQUENCY DISTRIBUTIONS OF STRONTIUM-90 IN PROCESSED MILK

Regional Characteristics of Strontium-90 in U.S. Milk

Figure 2 shows the four major geographic regions of the United States. Note that these regions correspond to those used by the Department of Agriculture for their tabulations of average "per person" quantities of foods consumed per week, as presented in *Radiological Health Data,* Volume I, Numbers 6 and 7. By this grouping, the stations located at Honolulu, Hawaii; Palmer, Alaska; and San Juan, Puerto Rico, have been excluded.

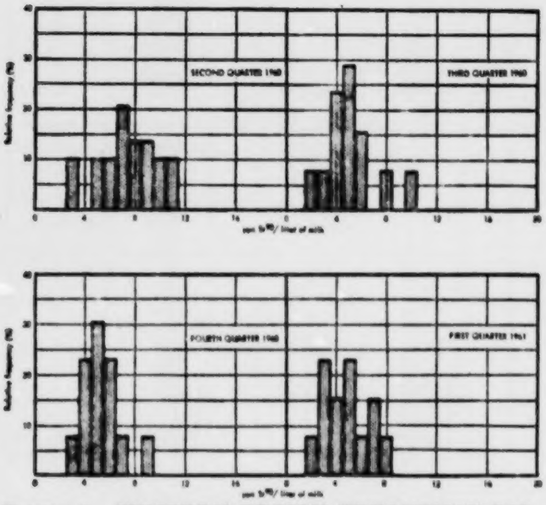


FIGURE 6.—WESTERN REGION FREQUENCY DISTRIBUTIONS OF STRONTIUM 90 IN PROCESSED MILK

Figures 3 through 6 illustrate the relative distributions of strontium-90 in processed milk in each of the four regions of the United States. For each region, four histograms are presented, one for each of the four quarters concerned within this presentation. The important statistics are included in table 4. Means, standard deviations, and relative frequencies were computed in the manner described in the previous section.

TABLE 4.—TABULATION OF PERTINENT STATISTICS FOR EACH REGION, STRONTIUM-90 IN U. S. PROCESSED MILK

Region	Period	No. of stations	No. of samples	Mean (μμc/liter)	Standard deviation (μμc/liter)
Northeast	2nd quarter 1960	12	26	11	3
	3rd quarter 1960	12	36	9	2
	4th quarter 1960	12	36	9	3
	1st quarter 1961	12	33	8	1
North Central	2nd quarter 1960	3	7	8	1
	3rd quarter 1960	13	36	7	1
	4th quarter 1960	13	38	7	1
	1st quarter 1961	13	38	6	1
South	2nd quarter 1960	6	10	8	3
	3rd quarter 1960	18	45	9	3
	4th quarter 1960	18	52	9	2
	1st quarter 1961	18	53	7	2
West	2nd quarter 1960	11	29	7	2
	3rd quarter 1960	13	38	5	2
	4th quarter 1960	13	39	5	2
	1st quarter 1961	13	39	5	2

A statistical comparison of the data, by the use of a "t-test" at the 5 percent significance level, reveals the relationships shown below for each region during each of the four quarters considered in this presentation. These relationships remain the same whether one assumes equal or unequal variance (μ_{NE} denotes the mean for the Northeast, . . .).

For each quarter the relationships are:

Second Quarter 1960	Third Quarter 1960
$\mu_{NE} > \mu_{NC}$	$\mu_{NE} > \mu_{NC}$
$\mu_{NE} > \mu_{S}$	$\mu_{NE} = \mu_{S}$
$\mu_{NE} > \mu_{W}$	$\mu_{NE} > \mu_{W}$
$\mu_{NC} = \mu_{S}$	$\mu_{NC} < \mu_{S}$
$\mu_{NC} = \mu_{W}$	$\mu_{NC} = \mu_{W}$
$\mu_{S} = \mu_{W}$	$\mu_{S} > \mu_{W}$

Fourth Quarter 1960	First Quarter 1961
$\mu_{NE} > \mu_{NC}$	$\mu_{NE} > \mu_{NC}$
$\mu_{NE} = \mu_{S}$	$\mu_{NE} > \mu_{S}$
$\mu_{NE} > \mu_{W}$	$\mu_{NE} > \mu_{W}$
$\mu_{NC} < \mu_{S}$	$\mu_{NC} < \mu_{S}$
$\mu_{NC} > \mu_{W}$	$\mu_{NC} > \mu_{W}$
$\mu_{S} > \mu_{W}$	$\mu_{S} > \mu_{W}$

Intra-region comparisons for each of the four quarters, using the statistical tests described in the preceding paragraph, show the relationships listed below. Similarly, these relationships are the same whether one assumes equal, or unequal variance (${}_2\mu_{60}$ denotes the mean for the second quarter of 1960.)

Northeast	North Central
${}_2\mu_{60} > {}_3\mu_{60}$	${}_2\mu_{60} \geq {}_3\mu_{60}$
${}_2\mu_{60} > {}_4\mu_{60}$	${}_2\mu_{60} \geq {}_4\mu_{60}$
${}_2\mu_{60} > {}_1\mu_{61}$	${}_2\mu_{60} > {}_1\mu_{61}$
${}_3\mu_{60} = {}_4\mu_{60}$	${}_3\mu_{60} = {}_4\mu_{60}$
${}_3\mu_{60} > {}_1\mu_{61}$	${}_3\mu_{60} > {}_1\mu_{61}$
${}_4\mu_{60} = {}_1\mu_{61}$	${}_4\mu_{60} > {}_1\mu_{61}$

South	West
${}_2\mu_{60} = {}_3\mu_{60}$	${}_2\mu_{60} > {}_3\mu_{60}$
${}_2\mu_{60} = {}_4\mu_{60}$	${}_2\mu_{60} > {}_4\mu_{60}$
${}_2\mu_{60} = {}_1\mu_{61}$	${}_2\mu_{60} > {}_1\mu_{61}$
${}_3\mu_{60} = {}_4\mu_{60}$	${}_3\mu_{60} = {}_4\mu_{60}$
${}_3\mu_{60} > {}_1\mu_{61}$	${}_3\mu_{60} = {}_1\mu_{61}$
${}_4\mu_{60} > {}_1\mu_{61}$	${}_4\mu_{60} = {}_1\mu_{61}$

The statistical relationships shown throughout the text constitute the conclusions of the authors. In no case was there ever a difference of more than 3μμc Sr^{90}/liter of milk between any two means or standard deviations. Special mention is made of this fact so that the reader is not mislead into assuming that large variations occur from one time period to the next, or from region to region.

REFERENCES

(1) *Radiological Health Data*, Volume I, Numbers 1–9 and Volume II, Numbers 1–10.

Strontium-90 In Bovine Milk From Minnesota

Division of Environmental Sanitation
Minnesota Department of Health

The Minnesota State Department of Health, Division of Environmental Sanitation, initiated a small bovine milk surveillance network in September 1958. Two-ounce samples, collected daily at each of the network stations, are composited and analyzed monthly. Collection is made at the bottling machines so that the sample is randomly representative of the milk produced in that milkshed.

Results for the period January-April 1960 were published in *Radiological Health Data*, Volume I, Number 9 and May-November 1960 in Volume II, Number 6. The most recently reported data from this network are presented below.

TABLE 1.—STRONTIUM-90 IN BOVINE MILK FROM MINNESOTA, DECEMBER 1960–MAY 1961

[Concentrations in μμc/liter]

Month	Brainerd	Duluth	Minneapolis	Thief River Falls	Worthington	Rochester
December 1960	15.3	14.1	5.1	....	5.3	6.0
1960 Average	16.0	13.3	7.1	9.3	6.9	6.8
January 1961	14.3	14.3	9.2	7.0	5.5	6.3
February 1961	....	12.6	6.7	6.7	6.4	6.4
March 1961	11.4	13.4	7.1	....	6.4	7.3
April 1961	10.3	14.4	6.6	5.8	6.3	5.1
May 1961	16.7	15.7	7.0	....	7.7	....

SECTION IV. — WATER

National Water Quality Network

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network operates under the provision of Section 4(c) of the Federal Water Pollution Control Act, which states ". . . The Secretary shall . . . collect and disseminate basic data . . . (relating) to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local agencies, and industrial organizations commenced operations in October 1957. At present, there are 86 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are on interstate, coastal, and International Boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of approximately 300 stations will be in operation. Radioactivity is not yet being reported for a few of the more recently established stations.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of the levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally-occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. During the cessation of weapons testing, the beta activity in most raw waters generally approached a level attributable solely to natural sources. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably in the data for the Columbia, Tennessee and Animas Rivers.

For the first two years of the network operations, beta determinations were made on weekly samples. Alpha determinations were reported generally on composites of more than one weekly sample.

Beginning January 1, 1960 the frequency of *beta* determinations has varied depending on the status of each particular station. For the first operating year of each new station, analyses have been conducted weekly. Weekly analyses are continued indefinitely from all stations which may be affected by waste discharges from nuclear installations. Semimonthly determinations (on composites of 2 or 3 weekly samples) are conducted for stations which still show some beta activity above background. Monthly determinations (on composites of all samples received from a station during the month) are conducted on samples from streams where beta activity is at background levels.

Beginning January 1, 1960, the frequency of *alpha* determinations has also been changed. For the first operating year of each new station, analyses have been done weekly. Semimonthly determinations are conducted at some collecting points on the Animas and Colorado Rivers by compositing 2 or 3 weekly samples. The remainder of the stations have determinations made quarterly on composites of all samples taken during that quarter. Schedules of determinations are so arranged that each river basin has one gross alpha determination each month.

All data reported in table 1 represent the average of all information available for the month indicated. Reported strontium-90 data are the results of determinations on composite samples for a three-month period ending in the month shown.

Additional information and data may be obtained from the following sources:

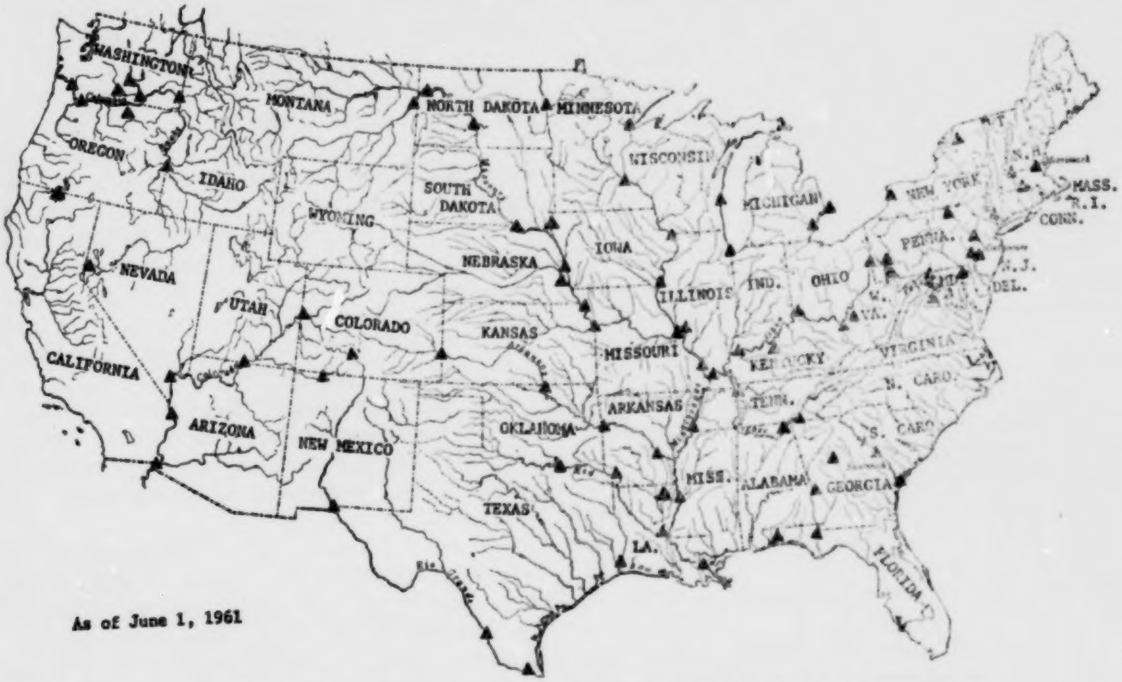
National Water Quality Network Annual Compilation of Data, PHS Publication. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price $1.50.

"Report on National Water Quality Control Network," submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167–169.

Setter, L. R., Regnier, J. E., and Diephaus, A., "Radioactivity of Surface Waters in the United States," Jour. AWWA *51*, 1377 (1959).

Straub, C. P., Setter, L. R., Goldin, S., and Hallbach, P. F., "Strontium-90 in Surface Waters," Jour. AWWA *52*, 756 (1960).

Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data*, Volume I, No. 7 (1960).


WASHINGTON
OREGON
MONTANA
IDAHO
NORTH DAKOTA
MINNESOTA
WISCONSIN
MICHIGAN
NEW YORK
N.H.
MASS.
R.I.
CONN.
SOUTH DAKOTA
WYOMING
NEVADA
UTAH
COLORADO
NEBRASKA
IOWA
ILLINOIS
IND.
OHIO
PENNA.
N.J.
DEL.
W. VA.
VIRGINIA
KANSAS
MISSOURI
KENTUCKY
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
LA.
FLORIDA

As of June 1, 1961

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS

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Table 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Concentrations in μμc/liter]

Station	Quarter ending March 31, 1961	April 1961					
	Strontium-90	Beta activity			Alpha activity		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	[a] —	0	0	0	<1	1	<1
Animas River: Cedar Hill, N. Mex	—	33	5	38	17	10	27
Apalachicola River: Chattahoochie, Fla	—	0	0	0	0	0	0
Arkansas River:							
Coolidge, Kans	—	0	3	3	8	80	88
Ponca City, Okla	—	0	0	0	10	2	12
Pendleton Ferry, Ark	—	0	0	0	1	0	1
Chattahoochie River:							
Atlanta, Ga	—	0	2	2	0	0	0
Columbus, Ga	0.3	0	0	0	1	<1	1
Colorado River:							
Loma, Colo	0.4	0	0	0	4	9	13
Page, Ariz	—	109	9	118	53	10	63
Boulder City, Nev	—	1	0	1	0	6	6
Parker Dam, Ariz-Calif	—	0	16	16	0	10	10
Yuma, Ariz	1.2	0	<1	<1	0	8	8
Columbia River:							
Wenatchee, Wash	0.7	0	3	5	0	1	1
Pasco, Wash	1.0	96	420	516	—	—	—
Bonneville Dam, Oreg	—	44	183	227	0	0	0
Clatskanie, Oreg	—	28	93	121	—	—	—
McNary Dam, Oreg	—	56	205	261	0	0	0
Delaware River:							
Martins Creek, Pa	—	0	0	0	1	0	1
Philadelphia, Pa	3.6	1	0	1	1	0	1
Great Lakes:							
Buffalo, N. Y	0.6	0	0	0	0	1	1
Port Huron, Mich	—	0	1	1	0	0	0
Detroit, Mich	—	0	0	0	0	1	1
Gary, Ind	—	0	0	0	0	0	0
Duluth, Minn	0.4	0	0	0	0	0	0
Milwaukee, Wis	—	3	4	7	0	0	0
Sault St. Marie, Mich	—	0	1	1	0	0	0
Hudson River: Poughkeepsie, N. Y	0.4	0	0	0	1	0	1
Illinois River: Peoria, Ill	—	0	0	0	0	2	2
Kanawha River: Winfield Dam, W. Va	0.2	0	0	0	0	0	0
Klamath River: Copco, Oreg	—	0	1	1	0	0	0
Little Miami River: Cincinnati, Ohio	1.1	0	0	0	1	1	2
Mississippi River:							
Minneapolis, Minn	—	0	1	1	0	2	2
Dubuque, Iowa	—	0	0	0	2	0	2
Burlington, Iowa	(b)	0	0	0	1	0	1
E. St. Louis, Ill	—	5	3	8	8	2	10
Cape Girardeau, Mo	0.7	34	0	34	19	0	19
West Memphis, Ark	—	0	0	0	1	1	2
Delta, La	(b)	2	0	2	3	1	4
New Orleans, La	—	22	0	22	13	0	13
Missouri River:							
Williston, N. Dak	0.8	0	0	0	2	5	7
Bismarck, N. Dak	—	0	0	0	0	0	0
Yankton, S. Dak	—	0	0	0	1	3	4
Omaha, Nebr	—	17	3	20	6	5	11
St. Joseph, Mo	—	19	8	27	8	3	11
Kansas City, Kans	1.4	0	0	0	9	5	14
St. Louis, Mo	1.1	26	2	28	33	2	35
Ohio River:							
East Liverpool, Ohio	—	0	0	0	1	0	1
Huntington, W. Va	—	0	0	0	1	1	2
Cincinnati, Ohio	0.3	2	0	2	2	0	2
Evansville, Ind	—	0	0	0	2	0	2
Cairo, Ill	—	6	1	7	1	0	1
Potomac River:							
Hagerstown, Md	—	0	7	7	0	0	0
Great Falls, Md	1.3	0	0	0	1	0	1
Red River, North: Grand Forks, N. D	—	1	2	3	<1	1	1
Red River, South:							
Index, Ark	0.4	0	0	0	9	0	9
Alexandria, La	—	36	0	36	28	0	28
Denison, Tex	—	0	0	0	0	2	2
Rio Grande River:							
Alamosa, Colo	—	0	0	0	0	0	0
El Paso, Tex	0.4	0	9	9	0	4	4
Laredo, Tex	0.4	0	0	0	1	6	7
Brownsville, Tex	—	0	0	0	5	4	9
Sabine River: Ruliff, Tex	—	<1	4	4	1	<1	1
St. Lawrence River: Massena, N. Y	—	0	0	0	0	0	0
Schuylkill River: Philadelphia, Pa	—	0	0	0	1	0	1
Savannah River:							
Port Wentworth, Ga	0.4	<1	3	3	1	0	1
North Augusta, S. C	—	0	0	0	0	0	0
Snake River:							
Wawawai, Wash	—	0	3	3	0	1	1
Weiser, Idaho	—	0	0	0	0	6	6
Susquehanna River:							
Sayre, Pa	—	0	0	0	1	0	1
Conowingo, Md	—	<1	2	2	0	0	0
Tennessee River:							
Chattanooga, Tenn	0.8	1	34	35	—	—	—
Bridgeport, Ala	1.5	0	31	31	0	0	0
Yakima River: Richland, Wash	—	0	0	0	0	0	0
Yellowstone River: Sidney, Mont	—	0	0	0	1	3	4

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[a] Dash denotes no sample received or no determinations made.

[b] Insufficient sample for Sr^{90} analysis.

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SECTION V. — OTHER DATA

External Gamma Activity

Radiation Surveillance Network, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and in instrument response characteristics.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, MAY 1961

Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Minneapolis, Minn	0.01
Fairbanks, Alaska	(*)	Pascagoula, Miss	(*)
Juneau, Alaska	0.01	Jefferson City, Mo	0.01
Phoenix, Ariz	0.02	Helena, Mont	0.03
Little Rock, Ark	0.02	Trenton, N. J	0.02
Berkeley, Calif	0.01	Santa Fe, N. Mex	(*)
Los Angeles, Calif	(*)	Albany, N. Y	0.09
Denver, Colo	0.02	Gastonia, N. C	0.02
Hartford, Conn	0.01	Oklahoma City, Okla	0.02
District of Columbia	0.02	Ponca City, Okla	0.02
Jacksonville, Fla	0.01	Portland, Oreg	0.02
Atlanta, Ga	(*)	Harrisburg, Penn	0.01
Honolulu, Hawaii	0.03	Providence, R. I	0.02
Boise, Idaho	[illegible]	Columbia, S. C	0.03
Springfield, Ill	0.03	Pierre, S. D	0.02
Indianapolis, Ind	0.01	Austin, Tex	0.01
Iowa City, Iowa	0.01	El Paso, Tex	0.02
Topeka, Kans	0.03	Salt Lake City, Utah	0.02
New Orleans, La	0.01	Richmond, Va	0.01
Baltimore, Md	0.02	Seattle, Wash	0.02
Lawrence, Mass	0.02	Madison, Wis	0.01
Lansing, Mich	0.02	Cheyenne, Wyo	0.02

* No data received.

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Cesium-137 Levels In Humans

Walter Reed Army Institute of Research, Washington, D.C., and
U.S. Army Medical Research Unit, Landstuhl, Germany

The whole body counting facilities at the Walter Reed Army Institute of Research (WRAIR), Washington, D. C., and the Medical Research Unit, Landstuhl, Germany, have continued their program for measuring the levels of cesium-137 in people. A description of each facility and previous data were summarized in *Radiological Health Data,* Volume II, Number 4; subsequent data appeared in Volume II, Number 7.

This report presents results from Germany for the period March through May 1961, and from Walter Reed for the second quarter of 1961. The Landstuhl data are listed by month in table 1 and the Walter Reed data are listed by geographic area in tables 2 and 3.

TABLE 1.—ASSAYS PERFORMED AT THE U. S. ARMY MEDICAL RESEARCH UNIT, LANDSTUHL, GERMANY

Date	Subjects residing in—	Number of subjects	$\mu\mu c\ Cs^{137}$/gm K (average)
March 1961	West Germany	216	37
April 1961	West Germany	85	43
May 1961	West Germany	234	37

TABLE 2.—ASSAYS PERFORMED AT THE WALTER REED ARMY INSTITUTE OF RESEARCH, SECOND QUARTER, 1961

Geographic area	Number of subjects	$\mu\mu c\ Cs^{137}$/gm K (average)
Australia	1	36
Caribbean	3	20
Europe	11	49
Far East	3	19
United States	75	32

TABLE 3.—ASSAYS OF INDIVIDUALS RESIDING WITHIN THE UNITED STATES PERFORMED AT WRAIR, SECOND QUARTER, 1961

State	Number of subjects	$\mu c\ Cs^{137}$/gm K (average)
Arkansas	1	29
California	1	10
District of Columbia	7	32
Florida	2	52
Georgia	1	46
Hawaii	1	31
Illinois	3	34
Indiana	2	25
Kentucky	2	30
Louisiana	1	31
Maine	1	23
Maryland	6	46
Massachusetts	2	37
Michigan	1	11
Minnesota	1	57
New Jersey	7	30
New York	12	30
North Carolina	1	27
Ohio	1	31
Pennsylvania	9	31
Rhode Island	1	26
South Carolina	1	27
Tennessee	2	21
Texas	3	19
Virginia	5	25
Wyoming	1	30

TABLE 4.—SUMMARY OF TABLES 1 AND 2—SECOND QUARTER, 1961

Geographic area	Number of subjects	$\mu\mu c\ Cs^{137}$/gm K (average)	Percent MPC[1]
Australia	1	36	0.18
Caribbean	3	20	0.10
Europe	11	49	0.25
Far East	3	19	0.10
West Germany	535	[2] 38	0.19
United States	75	32	0.16

[1] *Radiological Health Data*, Volume II, Number 4, pages 193 and 194.
[2] Values represent determinations for March through May 1961.

RADIOLOGICAL HEALTH CONSIDERATIONS AND FINDINGS RELATED TO THE USE OF MEDICAL AND DENTAL X-RADIATION

The following two articles are the second and third in a series of presentations intended to discuss or present information, philosophical considerations, or summaries of data concerning the radiological health aspects of medical and dental X-radiation. These discussions will be related primarily to the factors involved in the ultimate reduction of the somatic and genetic exposure dose delivered to the general population. The first article by Hanson

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Blatz, entitled, "Some Reflections on Current Plans to Control Radiation Exposure in the United States," appeared in *Radiological Health Data*, Volume II, Number 8. Mr. Blatz stressed that emphasis should not be placed on controlling exposure from radioisotopes to the exclusion of controlling exposure from machine-produced radiation.

In conducting field surveys of dental X-ray units, it is necessary to interpret and clarify the definition of a "diagnostic type protective tube housing" as recommended by the National Committee on Radiation Protection and Measurements in the National Bureau of Standards Handbook Number 76, February 1961, before a proper and realistic appraisal of the radiation leakage from such a housing can be accomplished. In the first of the two papers presented here, Mr. Edgar F. Seagle,[1] Program Operations Branch, Division of Radiological Health, Public Health Service, discusses practical considerations and a positive approach in accomplishing such an appraisal.

The author wishes to express his appreciation to George L. Crocker, D.D.S., James W. Miller, D.D.S., and Henry J. L. Rechen, Program Operations Branch, Division of Radiological Health, Public Health Service, for their valuable assistance.

The second of the two papers presented, by Mr. Herbert A. Bevis,[2] Texas State Department of Health, deals with, illustrates, and discusses data derived from a radiological safety survey of 140 dental X-ray units in Texas.[3]

Mr. Bevis expresses his appreciation to Dr. W. A. Buckner, Division of Dental Health and Mr. R. G. Griffin, Jr., Division of Occupational Health, Texas State Department of Health, and to Drs. G. A. Nevitt and J. T. Lovett, Public Health Service, Region VII, Dallas, Texas, for assisting in, and contributing to, the successful completion of this study.

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[1] At the present time, Mr. Seagle is assigned by the Public Health Service to the Florida State Department of Public Health.

[2] Mr. Bevis was assigned by the Public Health Service to the Texas State Department of Health, as Chief of the Ionizing Radiation Program, Division of Occupational Health, at the time this paper was prepared.

[3] A summary of the author's findings were also presented at the 36th Annual Meeting of the Texas Public Health Association at Fort Worth, Texas, held during March 5–8, 1961.

Measurement of Leakage Radiation From Dental X-Ray Tube Housings

Program Operations Branch
Division of Radiological Health, Public Health Service

Introduction

The purpose of this paper is to provide background material for survey teams who may try to determine compliance with paragraph 1, page 2 of National Bureau of Standards "Handbook, No. 76," entitled "Diagnostic Type Protective Tube Housing." This paragraph states that such a tube housing is an "X-Ray tube housing so constructed that the leakage radiation at a distance of one meter from the target cannot exceed 100 mr in one hour when the tube is operated at any of its specified ratings." The rating of a tube may be specified in terms of "continuous operation" or in terms of individual exposures with a duty cycle. As dental X-ray units are used to make individual exposures, the duty cycle for such exposures must be considered. To understand the above paragraph, one must be familiar with the individual terms included therein:

X-ray Tube Housing: The tenth edition of "Fundamentals of Radiography" (*1*) states that, "most diagrams of the X-ray tube show X-rays as forming a neat triangular pattern as they are produced at the focal spot. This serves a good purpose in emphasizing the action of X-radiation outside the tube. However, the radiation does not behave in that way. Actually, X-rays are like visible light in that they radiate from the source in straight lines in all directions unless they are stopped by an absorber. For that reason, the X-ray tube is enclosed in a metal "housing" that stops most of the X-radiation; only the useful rays are permitted to leave the tube through a window or port. These useful rays are called the "primary beam" (refer to figure 1).

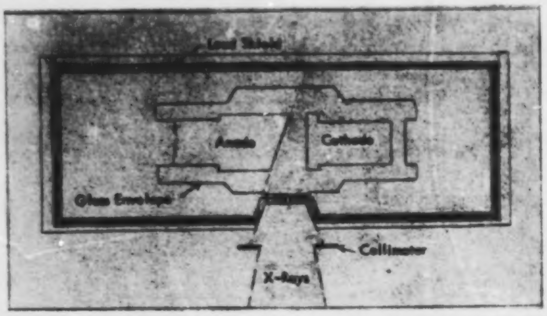

FIGURE 1.—DIAGRAM SHOWING THAT X-RAYS RADIATE IN STRAIGHT LINES IN ALL DIRECTIONS FROM THE SOURCE. THEREFORE, THERE IS NEED FOR THE METAL HOUSING AROUND THE TUBE [Courtesy of X-ray Division, Eastman Kodak Company (*1*).]

Leakage Radiation: According to the National Bureau of Standards Handbook No. 76, leakage radiation is all radiation coming from within the tube housing, *except* the useful beam. The useful beam is that portion of the radiation which passes through the window, aperture, cone, or other collimating device of the tube housing.

1 M: This term is the abbreviation for one meter. Its equivalent length is 3.2808 feet, or 39.4 inches.

Target: Quoting from "Fundamentals of Radiography" (*1*), "The simplest form of X-ray tube is a sealed glass envelope from which the air has been pumped and containing two important parts—the anode and the cathode. The anode is usually formed of copper and extends from the end of the tube to the center. A block of tungsten about one-half inch square is set in the anode face at the center of the tube. This is called the *target*. The small area of the target that the electrons strike is called the focal spot and it is the source of the X-rays."

100 mr in one hour: 100 mr is 100 milliroentgens or 0.1 of a roentgen. The roentgen is the unit of exposure dose of X- or gamma radiation. 100 mr *in* one hour means the total exposure dose at some specified location for one hour.

Specified ratings: The rating of an X-ray tube is the amount of time the tube can be mechanically operated safely during a single exposure. However, this gives no information as to how frequently exposures can be made. To provide this information, a duty cycle must be specified.

Duty Cycle: With regard to X-ray tubes, this term refers to the period of activation per unit time, (e.g., so many seconds in one minute), that a tube can be energized without damage to that tube. In other words, the tube may be energized so many seconds in each minute during the entire working day without exceeding the manufacturers' prescribed safe limits. This duty cycle will vary with the kilovolts peak potential (kvp) and the tube current, expressed in milliamperes (ma).

Significance of Duty Cycle Ratings to X-Ray Survey Teams

In the process of conducting a radiation safety survey of a dental X-ray installation, if one uses a suitable ion chamber type instrument with an energy response known for the quality of the X-rays generated and evaluates the exposure dose rate at 1 meter from the tube target as 100 mr per hour, an erroneous interpretation may be that this is the actual total leakage radiation delivered in that part of one hour. For this to be true, it would be necessary to activate the tube continuously for 1 hour. This is impractical, since no dental diagnostic X-ray tube is activated continuously for this length of time. Therefore, one must consider how long, or for what maximum time, a tube could be activated in 1 hour. Thus, the duty cycle becomes a significant consideration. For example, if the duty cycle should be 4 seconds of activation for each minute of continuous operation, the maximum time a well informed operator would activate the tube would be 4 minutes in 1 hour. Consequently, a true reading of 100 mr/hr, obtained on a unit with a 4 sec./min. duty cycle, would actually be a total of 6.66 mr in 1 hour, based on the length of time the tube could be activated in that hour.

It is evident from the following simple calculation that to obtain a total of 100 mr in 1 hour, from a unit with a 4-second-per-minute duty cycle, the "true" exposure dose measured at one meter would have to be 1500 mr/hr:

$$\frac{100\ \text{mr/hr}}{6.66\ \text{mr total}} = \frac{x}{100\ \text{mr total}}$$

$$6.66\,x = 10{,}000$$

$$x = 1500\ \text{mr/hr}$$

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TABLE 1.—DUTY CYCLE RATINGS FOR DENTAL X-RAY UNITS[1]

Company	Model	Current (ma)	Voltage (kvp)	Duty Cycle (Continuous Operation)	Conversion Factor[2]
Ritter	A	10	65	6.5 secs. each min	0.1082
	B	10	50-70	4.5 secs. each min	0.0749
	Dual—X	15	70	4 secs. each min	0.0666
	E (Century)	15	90	3.6 secs. each min	0.060
	F	15	90	do	0.060
G. E.	Victor (Old Style)	10	58	Unknown	
	CDX-E	10	65	Unknown	
	70	10	70	3½ secs. at 2 ea. min	0.1165
	90-II	15	90	4 secs. each min	0.0666
XRM	2A	15	70	do	0.0666
	3A	15	70	do	0.0666
	90	15	90	do	0.0666
Weber	6	10	65	6 secs. each min	0.10
	6A	10	65	do	0.10
	6B	10	65	do	0.10
	6R	10	65	do	0.10
	7	10	65	do	0.10
	7A	10	65	do	0.10
	9A	10	65	do	0.10
	11	10	65	do	0.10
	11E	10	65	do	0.10
	Raydex (70)	10	70	4.5 secs. each min	0.0749
	Raydex 12R (90)	15	90	3 secs. each min	0.050
Fischer		10	65	4 secs. each min	0.0666

[1] The information listed in this table has been obtained from personal communications (4-9).

[2] Multiply the "true" exposure dose rate determined at one meter from the tube target by the correction factor to obtain the quantity of leakage radiation in 1 hour.

These relationships show that for a duty cycle of 4 seconds per minute, the total leakage radiation in one hour would be 6.66 percent of the reading shown on the ion chamber. A percentage factor in multiplying the ion chamber reading should be computed for each individual duty cycle. This has been done for the most common dental units. Calculations were based on the assumption that operators of dental X-ray units do adhere to the specified duty cycle. The kvp and ma settings shown for the various makes of dental X-ray units in table 1 are not unreasonably representative of those actually employed.

A good average conservative estimate of the correction factor seems to be 0.1. Therefore, it would not be inappropriate to apply this factor to such other units as the Philips Oralix, Universal, Westinghouse, Meyer, Wappler, Grenz-Ray, and Norelco. This figure may also be used by inspectors as a conversion factor for models listed in table 1 where specific information for a given unit is unknown. For example, the duty cycle and conversion factor for a 15 ma and 90 kvp unit may be given, but if the unit is operated at less than 15 ma and 90 kvp the conversion factor has not been calculated. In all such cases it is recommended that one use 0.1. This figure is a conservative average and allows for a maximum safety factor of approximately 2.0.

Conclusion

The results of this investigation show that the duty cycle must be known, and it must be considered in order to obtain a practical appraisal of the leakage radiation from dental X-ray tube housings as defined in the recommendations stated in Handbook No. 76 (*4*).

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Radiation Hygiene In Dental Offices Of Texas

Division of Occupational Health, Texas State Department of Health

Discussion

Public interest has been stimulated by hazards associated with exposure to ionizing radiation. The public has been constantly exposed to a barrage of information and misinformation concerning the biological effects of radiation. As a result, some people have become so concerned that they are hesitant to submit to X-ray examinations, even when they are recommended by physicians or dentists.

If it could be stated authoritatively that radiation presented no hazard to those individuals exposed, these fears could probably be dispelled. However, most experts agree that all radiation exposure is potentially injurious—not only to the person exposed, but to his decendants as well. The medical and dental use of X-radiation is the greatest source of exposure to the public (*1*). It is the responsibility of these professions to constantly re-evaluate their use of radiation equipment and techniques in order to be certain that their exposure of the public, and of assistants and themselves, is kept to an absolute minimum.

Table 1.—RESPONSE OF DENTISTS

District	Number of members	Number of survey requests	Percent participation
1	43	23	54
14	64	36	56
15-B	46	36	78
21-A	33	24	73
Total	186	118	63

Studies have been conducted to ascertain the radiation exposure to dental patients, (*2*) and to dental office personnel (*3, 4, 5*). The American Academy of Oral Roentgenology (AAOR) and the National Committee on Radiation Protection and Measurements (NCRP&M) have offered recommendations to reduce these exposures (*6, 7*). Generally speaking, steps taken to reduce exposure to the patient will also reduce exposure to office personnel. The converse is usually true as well.

The Texas State Department of Health, in cooperation with the Texas Dental Association and the Public Health Service, Department of Health, Education, and Welfare, conducted a study to determine the status of radiation protection practices in dental offices of Texas. Component society districts (1, 14, 15-B and 21-A) of the Texas Dental Association were selected as loci for this investigation. It is felt that dental offices in these districts are representative of the State, and data obtained in this study can be considered typical of dental X-ray-installations in Texas.

Table 2.—CONDITION OF X-RAY EQUIPMENT

Statistic	District				Sum	Percent of total
	1	14	15-B	21-A		
Number of X ray units	31	40	42	27	140	
Initially satisfactory	3	1	4	3	11	8
Inadequate filtration[a]	24	37	33	24	118	84
Excessive beam diameter[b]	16	26	27	18	87	62
Non-radiation effects[c]	4	5	3	0	12	9
Units corrected[d]	24	34	35	24	117	84

[a] The AAOR's recommended value of 2.0 mm total aluminum equivalent filtration was used.

[b] The AAOR's recommended beam diameter of ¾ inches at the tip of the pointer cone was employed.

[c] "Non-radiation defects" include: electrical by-pass timer, inadequate grounding of electrical components, exposed electrical wiring; mechanical instability of X-ray tube head.

[d] The Texas Dental Association provided the lead and aluminum for fabricating the diaphragms and filters. The latter were fabricated by the Texas State Department of Health. The dies were designed by Mr. Bevis.

Summary of Results

Prior to initiating any field surveys in an area, the local dental society was informed of

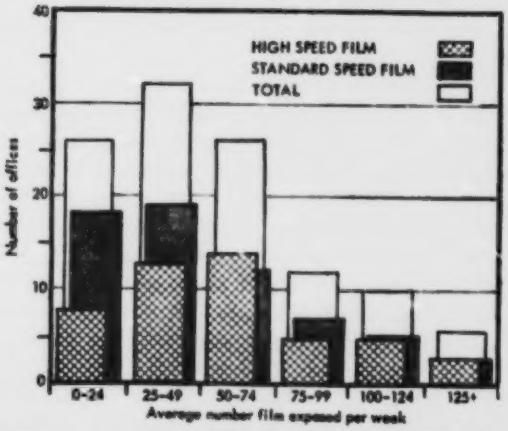

Figure 1.—DISTRIBUTION OF THE NUMBER OF X-RAY FILMS EXPOSED WITH FILM SPEED AS THE PARAMETER

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the program and their cooperation was solicited. An explanatory letter and a reply post card were sent to each member of the local society. Radiological surveys were made of the offices of only those dentists who specifically requested such services by return of the post card. These cards requested preferred times for office visits, and some basic information about the X-ray units to be surveyed. Tables 1 and 2, and figure 1 present some of the results obtained in this study. The survey team which visited each office consisted of two people.

The response of dentists from the districts selected for study is presented in table 1. It should be noted that invitations were sent to all members of the local societies. This membership includes retired dentists as well as others not actively engaged in the practice of dentistry. Consequently, the composite response of 63 percent is better than it would appear.

A number of those dentists who did not request a survey of their offices may have recently purchased X-ray units. Some are under the impression that all new or reconditioned X-ray equipment automatically meets the recommended standards. Unfortunately, this is not true. Of the 140 X-ray units inspected during the course of this study, only 11 units (less than 8%) met the recommendations of the National Committee on Radiation Protection and Measurements and the American Academy of Oral Roentgenology. Defective equipment ranged from ultra-modern high voltage units to antiquated glass bowl devices with exposed high voltage lines.

It was found that the five-foot length recommended for switch cords is difficult to evaluate. In some instances, cord lengths somewhat less than five feet would have appeared to be satisfactory. Frequently however, cord lengths greater than five feet would be desirable. Most dental operatories are small and rather cramped. As a result, it is usually impossible to make full use of the cord length because of the location of the X-ray unit and the amount of other specialized equipment located in the room. Much can be said in favor of the new coil-type cords which will generally extend considerably more than five feet.

It is interesting to note that of the 140 X-ray units checked during this survey, only three were high voltage (90 kvp) units. One of these units was being operated at 65 kvp.

The extent X-ray examinations were used by the study group is indicated in figure 1. Several dentists who had requested a radiation survey of their offices reported that they did not normally take X-rays even though they owned functional equipment. At the other extreme, one dentist reported that he averaged about 400 exposures per week. The largest percentage of offices visited expose between 25 and 50 films per week.

Only 43 percent of the dentists were using "fast" film at the time of the inspection. A number of others stated that they had tried the fast film, but they were not satisfied with the quality of the radiograph. Some of those currently employing fast film were erroneously approximating the same exposures as used with regular speed film, and were reducing the developing time accordingly.

In monitoring the positions occupied by X-ray personnel during typical examinations, it was noted that most personnel realize the importance of keeping out of the primary beam. However, they were not cognizant of the hazard resulting from radiation scattered by the patient. The operator would frequently stand immediately behind the X-ray tube head which was approximately two or three feet from the patient. As a result, they were exposed to much higher levels of radiation than was necessary. It was ascertained, in most cases, that the best position for the operator during all types of X-ray examinations was directly behind the dental chair, as far as from the patient as the cord would allow. Although this position might be obvious for bitewing X-rays, it was found to be equally preferred for exposures with the beam pointed toward the rear. Evidently, the increased distance which this position affords more than compensates for any increased scatter in that direction.

Even though this study indicated that the operator position described above was preferred in a large number of cases, it would not necessarily hold true for all operatories. Radiation scattering is a very complex phenomenon which involves the design of the room and the actual arrangement of equipment. In reality, the only way to accurately evaluate an installation

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is by measuring radiation levels at various positions with an appropriate radiation detection instrument.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission submits to the Public Health Service quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 17 AEC installations have appeared in *Radiological Health Data*, Volume I, Numbers 8 and 9; and Volume II, Numbers 1 through 9. Summaries follow for Shippingport Atomic Power Station and Bettis Atomic Power Laboratory, third and fourth quarters of 1960.

The measured concentrations of radioactive substances in air and water may be compared with the Maximum Permissible Concentration (MPC) of that substance as recommended by the National Committee on Radiation Protection and Measurements (NCRP&M). For the general population, the applicable MPC's are one-tenth of the occupational values for continuous exposure as given in National Bureau of Standards "Handbook Number 69."

For the purpose of clarity and perspective, a few of the applicable environmental MPC values are listed in table 1 below. Such values are intended as guides only. For further clarification, "Handbook 69" should be consulted.

When various radioactive substances are considered separately the following relationship should be satisfied:

$$\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \frac{C_C}{MPC_C} + \ldots\ldots < 1$$

in which C_A is the actual concentration of substance "1" and MPC_1 is its appropriate MPC, etc.

TABLE 1.

Radioactive substance	Environmental MPC's	
	Water ($\mu\mu c$/liter)	Air ($\mu\mu c/m^3$)
Gross activity of unidentified nuclides	10	0.04
Gross activity in water if Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-natural are not present*	2,000	--------
Airborne particulate activity if there are no α-emitters and if Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present*	--------	100
Hydrogen-3 (Tritium)	3,000,000	200,000
Strontium-90	100	10
Xenon-133	--------	300,000

* The term "not present" implies that the concentration of the radionuclide is small compared to its approximate MPC as listed in "Handbook 69."

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Bettis Atomic Power Laboratory

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania
Issued December 1960 and February 1961

Environmental levels of radioactivity at the Bettis Atomic Power Laboratory for 1959 and the first and second quarters of 1960 were reported in *Radiological Health Data*, Volume I, Number 8, and Volume II, Number 1. The following report presents the data for the third and fourth quarters of 1960 together with averages for the calendar year.

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission (AEC) by the Westinghouse Electric Corporation, was established in 1949. Since that time, BAPL has been engaged in research and development work related to naval atomic propulsion systems and the central station atomic power reactor at Shippingport.

Measurements are continually made to insure that controls on laboratory processes are adequate to prevent the release of radio active materials to the surrounding community. Measurements are also made in the area surrounding the laboratory in order to determine background levels of radioactivity. These measurements have shown that laboratory controls were effective in minimizing the release of radioactivity to the environment.

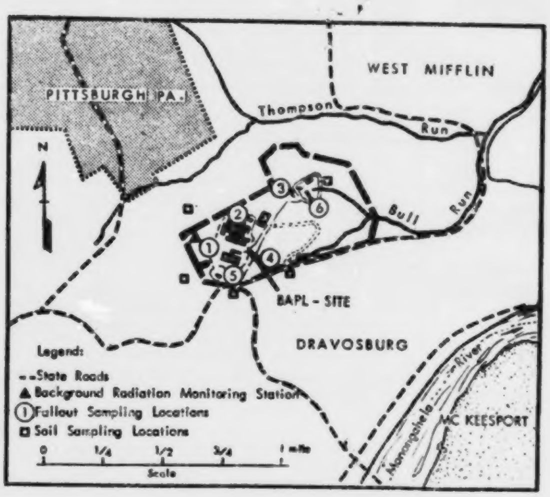

FIGURE 1.—BETTIS ATOMIC POWER LABORATORY SAMPLING STATIONS

Liquid Radioactive Waste Disposal

Laboratory liquid effluent is sampled continually and analyzed as a weekly composite. Its measured concentration may include fallout from rainfall and runoff that has entered the effluent line through the laboratory drainage system. Table 2 presents the concentrations of gross radioactivity and strontium-90 concentrations in the liquid effluent of the plant for third and fourth quarters, 1960. Calendar year averages are also included.

TABLE 2.—GROSS RADIOACTIVITY AND STRONTIUM-90 CONCENTRATIONS IN LIQUID WASTES, 1960

[Average concentrations in μμc/liter]

Period	Gross radioactivity[2]	Strontium-90
Second quarter	----	2.4
Third quarter	120	1.4
Fourth quarter	170	1[illegible].0
Calendar year	170	4.7

[1] The concentration of strontium-90 for the second quarter is included in this report because the analysis had not been completed in time to be included in its respective report. (See *Radiological Health Data* Volume II, Number 1.)

[2] The MPC used here for gross radioactivity is 2,000 μμc/liter (see table 1 in the introduction to these reports on AEC installations) because Sr^{90} is considered separately using the formula

$$\frac{C_A}{MPC}+\frac{C_B}{MPC}\leq 1$$

Where C_A is the concentration of gross radioactivity, and C_B is the concentration of strontium-90.

Beta-Gamma Background Radiation Levels

Beta-Gamma background radiation levels are continuously monitored and recorded at a monitoring station located inside the western boundary of laboratory property as shown in figure 1. The results of the data taken during the third and fourth quarters of 1960 are listed in table 3.

The background radiation levels in table 3 are within the range 0.01 to 0.04 mr/hr as measured in December 1960 by the Radiation Surveillance Network, Public Health Service, throughout the United States.

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TABLE 3.—BETA-GAMMA BACKGROUND RADIATION LEVELS, 1960

[Average dose rate in millirads/hour]

Period	Beta-gamma background
Third quarter	0.017
Fourth quarter	0.018
Calendar year	0.017

Fallout

Radioactive fallout samples are collected at the six stations shown in figure 1. Measurements of fallout collected by these stations provide only approximate values that are useful in indicating trends or variations. Due to their locations, these stations measure not only day-to-day fallout from the atmosphere, but also may detect resuspended activity present in dust particles caused by the movement of vehicles and construction work in the immediate vicinity. Table 4 shows the data obtained from analyses of samples collected at these stations during the third and fourth quarters of 1960.

TABLE 5.—ALPHA AND BETA ACTIVITY IN SOIL, 1960

[Average concentrations in $\mu\mu c$/gram]

Period	Alpha	Beta
Fourth quarter	67	27
Calendar year	42	26

Based on prevailing wind directions, the sampling locations have been categorized as upwind or downwind, and the data are compared in an effort to determine what effect laboratory operations have in surrounding areas. The results reveal no significant differences that would indicate that the laboratory is contributing to fallout in the surrounding areas.

At the beginning of the fourth quarter, the method of collecting fallout samples was changed from gummed film, exposed for one week, to high-walled pots exposed for one month.

Soil Sampling

Soil samples from five locations shown in figure 1 are collected each year during the second and fourth quarters. Concentrations of radioactivity in the soil samples collected during the fourth quarter are shown in table 5.

TABLE 4.—AVERAGE BETA ACTIVITY IN FALLOUT, 1960

[Average concentration in mc/mi^2/month]

Period	Station							
	Upwind			Downwind				
	No. 1	No. 5	Average	No. 2	No. 3	No. 4	No. 6	Average
Third quarter	2	2	2	3	2	3	2	3
Fourth quarter	2	2	2	3	3	2	2	3
Calendar year	----------	----------	4	----------	----------	----------	----------	4

Shippingport Atomic Power Station

Duquesne Light Company, Shippingport, Pennsylvania
Issued December 1, 1960 and March 1, 1961

Environmental levels of radioactivity at the Shippingport Atomic Power Station for 1959, and the first, and second quarters of 1960 were reported respectively in *Radiological Health Data*, Volume I, Numbers 4 and 9 and Volume II, Number 1, respectively. The following report presents a summary of the data for the third and fourth quarters of 1960, and averages for the calendar year of 1960.

The Shippingport Atomic Power Station, operated for the Atomic Energy Commission by the Duquesne Light Company, is the first large-scale nuclear-powered electric generating station. The plant resumed operations in May

1960 after a "shut-down" which lasted nearly six months, so that a portion of the reactor fuel could be replaced. Following this refueling, the plant operated at various power levels for nearly 4400 hours, and in 1960, it produced over 255 million kilowatt hours of electrical energy.

Liquid Radioactive Waste Monitoring

At Shippingport, most of the liquid wastes are discharged according to the limit for gross unidentified mixtures of radionuclides. This is done because the total quantity of radioactivity in the waste is of a low level and analyses for many specific radionuclides are laborious and expensive. However, the discharge of tritium is controlled separately, based on its own maximum allowable limit, since its formation in the reactor can be predicted with relative ease. These controls are applied to the actual plant discharges. No allowance is made for the dilution available in the environment except for that river water actually pumped through the plant for cooling the condensers.

TABLE 6.—SUMMARY OF GROSS RADIOACTIVITY RELEASED TO THE OHIO RIVER, 1960

Period	Total for month (μc)	Average per day (μc)	Average concentration effluent channel during release (μμc/liter)
Third quarter:			
July	9,506	309	2.3
August	7,275	234	1.9
September	11,881	395	2.9
Fourth quarter:			
October	20,305	655	3.0
November	8,198	273	2.4
December	10,486	338	3.4
1960 summary:			
First quarter	----------	735	5.8
Second quarter	----------	799	4.3
Third quarter	----------	313	2.4
Fourth quarter	----------	422	2.9
1960 average	----------	567	3.8

TABLE 7.—SUMMARY OF TRITIUM RELEASED TO THE OHIO RIVER, 1960

Period	Total for month (curies)	Average per day (curies)	Average concentration in effluent channel during release (μμc/liter)
Third quarter:			
July	6.847	0.220	2,900
August	16.756	0.541	7,000
September	15.650	0.522	7,600
Fourth quarter:			
October	26.477	0.855	7,100
November	16.158	0.538	7,400
December	8.703	0.280	7,100
1960 summary:			
First quarter	----------	0.00	0
Second quarter	----------	0.03	1,100
Third quarter	----------	0.43	3,300
Fourth quarter	----------	0.58	7,200
1960 average	----------	0.26	2,900

Tables 6 and 7 summarize the average gross radioactivity and tritium concentrations in the plant effluent channel during the third and fourth quarters, 1960. A review of the cal-

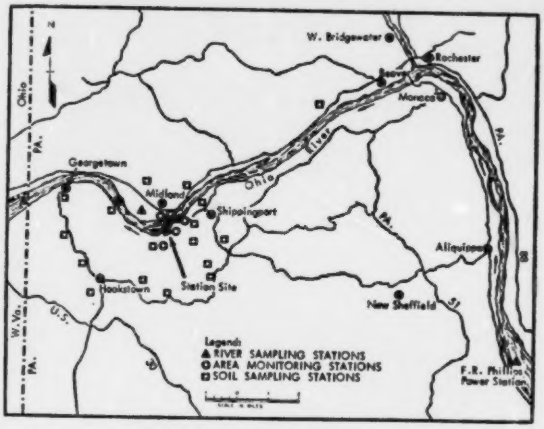

FIGURE 2.—SHIPPINGPORT POWER STATION, SAMPLING LOCATIONS

TABLE 8.—GROSS ALPHA AND BETA CONCENTRATIONS IN THE OHIO RIVER, 1960

[Average concentrations in μμc/liter]

Station	Third quarter							Fourth quarter						
	Number of samples	Suspended		Dissolved		Total		Number of samples	Suspended		Dissolved		Total	
		Alpha	Beta	Alpha	Beta	Alpha	Beta		Alpha	Beta	Alpha	Beta	Alpha	Beta
Upstream:														
Phillips	13	0.1	1.9	0.5	8.2	0.6	10.1	13	0.3	2.5	0.9	6.5	1.2	9.0
Shippingport	13	0.2	2.3	0.9	8.0	1.1	10.3	13	0.2	2.1	0.9	7.1	1.1	9.2
Downstream:														
Midland	13	0.1	1.6	0.6	8.1	0.7	9.6	13	0.2	2.2	0.4	7.0	0.6	9.2
E. Liverpool	13	0.6	4.5	1.2	7.1	1.8	11.6	13	0.1	2.7	0.5	7.2	0.6	9.2
Dam #7 (grab sample)	13	0.2	1.9	0.7	7.7	0.9	9.6	12	0.1	2.3	1.0	7.8	1.1	10.1

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endar year of 1960 is also included in the tables.

River water samples are taken continuously at four locations upstream and downstream from Shippingport and they are analyzed weekly. Upstream sampling stations are located at the Phillips Power Station of the Duquesne Light Company (about 20 miles upstream) and at the condenser cooling water intake at Shippingport. The downstream continuous sampling stations are on the water intake lines of the water treatment plants at Midland, Pennsylvania, and East Liverpool, Ohio, approximately one and eight miles downstream, respectively. Weekly grab samples are also collected from the River at Dam Number 7. These locations are shown in figure 2.

TABLE 9.—SUMMARY OF AVERAGE GROSS BETA CONCENTRATION IN THE OHIO RIVER DURING 1960

[Average concentrations in μμc/liter]

Station	First quarter	Second quarter	Third quarter	Fourth quarter
Upstream	10	9	10	9
Downstream	11	9	10	10

Table 8 presents a summary of the gross alpha and beta concentrations of suspended and dissolved solids in the Ohio River during the third and fourth quarters, 1960. Table 9 reviews the gross beta concentrations for the calendar year 1960. About 60 percent of the beta activity shown in tables 8 and 9 has been shown to be potassium-40, which is part of the natural background.

Area Monitoring

During the third and fourth quarter of 1960, small quantities of gaseous radionuclides were released to the atmosphere from the waste disposal system.

In July, a total of 5,424 microcuries, composed primarily of xenon-133, were discharged at a controlled rate over a period of four and one-half hours. This gaseous waste had an average concentration of 79,000 μμc/m^3 of air at the stack exit during release. In December, a total of 23,555 microcuries also composed primarily of xenon-133, were discharged at a controlled rate over a period of 114 hours and 18 minutes. In this case, the average concentration was 13,000 μμc/m^3.

TABLE 10.—AIRBORNE PARTICULATE RADIOACTIVITY, 1960

[Average concentrations in μμc/m^3]

Period	Station				Average of all stations
	Upwind		Downwind		
	¼ mi. SW of site	¼ mi. NW of site	On site, SE of main bldg.	¼ mi. NE of site	
Third quarter	2.5	1.7	1.7	2.3	2.0
Fourth quarter	2.0	1.7	1.4	2.4	1.9
Calendar year	----------	----------	----------	----------	1.5

An incinerator employed for burning contaminated combustible material is located in the waste disposal plant and it is generally used several times a month. The exhaust from the incinerator passes through a wet gas scrubber and a filter to remove any particulate radioactivity before entering the exhaust stack. It is monitored at the stack exit in order to record the levels of radioactivity leaving the plant. During the third and fourth quarters of 1960, the maximum radioactivity monitored at the stack exit during incinerator operations was 100 μμc/m^3. This level was noted and the average activity discharged that day was 3.4 μμc/m^3.

Four area monitoring stations continuously monitored and recorded background levels of beta-gamma radiation and airborne particulate radioactivity in the vicinity of Shippingport. (See tables 10 and 11). These stations are shown in figure 2. The data recorded by each station were checked and tabulated weekly. The data reported in table 10 are the results of measurements made only one hour after

TABLE 11.—GROSS BETA-GAMMA BACKGROUND RADIATION LEVELS, 1960

[Average values in millirad/hour]

Period	Station				Average of all stations
	Upwind		Downwind		
	¼ mi. SW of site	¼ mi. NW of site	On site, SE of main bldg.	¼ mi. NE of site	
Third quarter	0.014	0.014	0.015	0.014	0.014
Fourth quarter	0.012	0.013	0.012	0.012	0.012
Calendar year	----------	----------	----------	----------	0.013

Table 12.—GROSS BETA ACTIVITY IN FALLOUT, 1960

[Average concentrations in mc/mi²/mo.]

Period	Station				Average of all stations
	Upwind		Downwind		
	½ mi. SW of site	½ mi. NW of site	On site, SE of main bldg.	½ mi. NE of site	
Third quarter	12.5	1.7	7.8	1.5	5.8
Fourth quarter	6.5	11.0	6.8	8.1	8.1
Calendar year	9.1	8.5	8.5	8.3	8.6

sample collection, and therefore, natural radon activity would be included.

Fallout

Radioactive fallout is collected at the four area monitoring stations. Samples are picked up weekly for analyses of their gross beta radioactivity. The data for the third and fourth quarter and the calendar year averages are presented in table 12. The prevailing wind direction at Shippingport is generally from west to east. Data from the upwind stations are compared with that from the downwind stations in an effort to determine any effect which can be attributed to plant operations. These results do not indicate a contribution to fallout in the area from the Shippingport plant during 1960.

Table 13.—GROSS ALPHA AND BETA ACTIVITY IN SOIL SAMPLES

[Average concentrations in μμc/gm]

Period	Alpha	Beta
Third quarter, 1960	12	14
Fourth quarter, 1960	18	15
Calendar year, 1960	16	15
Preoperational, (1956-57)	15.4	15.8

Soil Sampling

Soil samples were collected from twenty locations within a radius of approximately five miles of the Shippingport site during the third and fourth quarters of 1960. A comparison of this data with that taken during the preoperational survey shows no significant increase in soil concentrations.

Latitudinal Distribution of Strontium-90 [1]

Soil Conservation Service, U.S. Department of Agriculture; Health and Safety Laboratory, U.S. Atomic Energy Commission; and Weather Bureau, U.S. Department of Commerce

Sampling Sites and Methods

Sampling sites within the continental United States and other locations throughout the world have been selected to measure the total amount of strontium-90 fall-out in soil. The sites are level, or nearly so, have a complete vegetative cover, and are sufficiently permeable to absorb all the precipitation that falls on them. These sites receive no water from higher ground. The depth of sampling has increased in successive years because there has been some penetration of Sr^{90} downward into the soil with time. A 1959 study of penetration at a sandy site, where greater than average penetration was expected, indicated that 74 percent of the Sr^{90} was in the top 2 inches, 88 percent in the top 4 inches, 94 percent in the top 6 inches, and 97 percent in the top 8 inches. Trace amounts of Sr^{90} were reported to a depth of 16 inches. The sampling depth has been adequate in all cases to ensure that no significant amount of Sr^{90} was below the sample.

Every precaution has been taken to minimize the effect of redistribution that may have taken place since deposition. For example, sampling sites were not located in New Mexico, Nevada, and Wyoming because of the general redistribution of Sr^{90} due to the shifting of the surface soil by wind action. Some places lose material by wind action while others gain, but there is no simple way of determining the extent of this distribution. This may not be true of the complete area of these states, but it applies to the drier, more representative regions. To some extent, the blowing and drifting of the winter snows have a similar effect. However, errors due to redistribution are not thought to be serious in the sampling sites.

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[1] Abstracted from "Strontium-90 on the Earth's Surface," U.S.A.E.C. TID 6567 February 1961.

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The samples were taken with two instruments, one is a "cookie cutter" that removes a 3.5-inches core to a depth of 2 inches. The other is an orchard auger which cuts a hole the same diameter as the cookie cutter, and removes the soil to the desired depth from its beginning depth of 2 inches. In some of the foreign samplers, Australia for example, the auger has a somewhat larger diameter. In all cases, the error in the measurement of the sampled area is not greater than about 1 or 2 percent.

The sample includes both living and dead vegetation. The final sample for analysis includes the proper fraction of any vegetation that segregates during sample preparation. Likewise, all rocks are crushed and included in the analyzed sample. The sample is usually a composite of 20 individual cores. The weight of sample ranges from 20 or 30 pounds for highly organic or peaty soils, to as much as 100 pounds for high-volume-weight soils taken to a depth of 10 inches.

Latitudinal Distributions of Strontium-90 Fallout

Figure 1 illustrates the latitudinal distribution of fall-out obtained from soil samples in 1956, 1958, and 1959. All the North-South profiles show the same general features: a pronounced peak in the 30 to 60°N band, a minimum in the equatorial region, and a weak secondary maximum in the Southern Hemispheric 30 to 60°S band. The reality of the secondary peak in the southern hemisphere is of some importance in the meteorological interpretation of the transport of stratospheric debris. Additional evidence for this

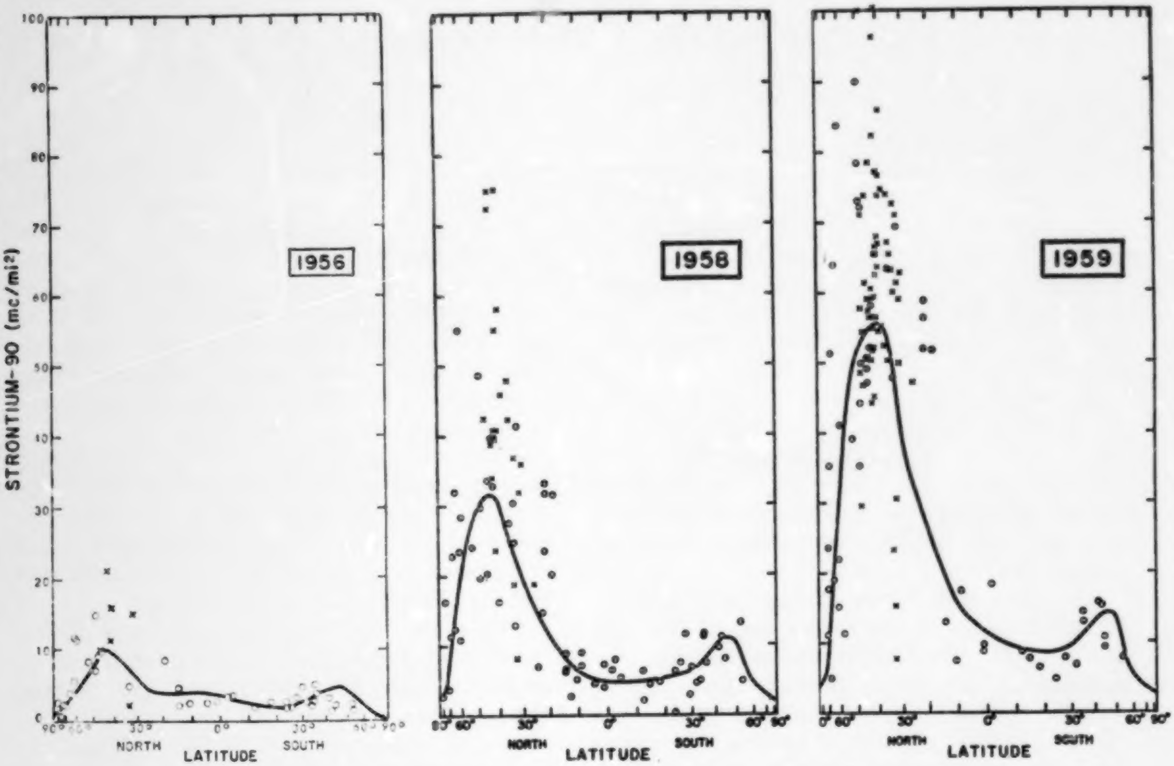

FIGURE 1.—SOIL STRONTIUM-90 AS A FUNCTION OF LATITUDE. CROSSES INDICATE SAMPLES COLLECTED IN THE CONTINENTAL UNITED STATES.

secondary maximum is given by the Naval Research Laboratory 80th meridian ground-level air-concentration measures (*1*), and to a limited extent by the Sr^{90} concentrations in rainfall (*2*).

Comparison With Production

A complete analysis of the inventory of Sr^{90} is beyond the scope of this report. However, other estimates (*3*) seem to be consistent with the soil data. The total production (*3*) of Sr^{90} to 1959 is given as 9.2 megacuries, assuming that 1-megaton equivalent fission energy corresponds to 0.1 magecuries of Sr^{90}. It has been estimated (*3*) that about 3.0 megacuries fell out in the first few hundred miles downward of the test sites as local fall-out. This fall-out is not considered to be part of the world-wide Sr^{90} deposition. The remaining 6.0 to 6.5 megacuries would have decayed to between 5.5 and 6.0 megacuries as of July 1959. The analysis of the soil data suggests that 4.1 megacuries have already been deposited. Knowledge of the atmospheric content is limited, but using the stratospheric baloon observations mainly in the period January to July 1959, it is estimated that 1.0 to 1.5 megacuries still remained in the stratosphere. The sum of the soil evaluation, 4.1 megacuries, and the uncertain stratospheric reservoir, 1.0 to 1.5 megacuries, is close to the estimate of world-wide Sr^{90}, 5.5 to 6.0 megacuries.

REFERENCES

(*1*) Lockhart, L. B., Jr., et al., Radiochemical Analyses of Air-Filter Samples Collected During 1958, Naval Research Laboratory, Report No. 5390, October 1959.

(*2*) Hardy, Edward P., Jr., and Klein, Stanley, Strontium Program, Quarterly Report, HASL-77, Hardy, Edward P., Jr., and Klein, Stanley, Fall-Out Program Quarterly Summary Report, HASL-84.

(*3*) "Fallout From Nuclear Weapons Tests, Summary Analysis of Hearings, May 5–8, 1959," U.S. Congress Joint Committee on Atomic Energy, pages 11 and 40, August 1959.

Savannah Estuary Environmental Radiological Survey

Division of Radiological Health, Public Health Service

The Public Health Service, and the Bureau of Commercial Fisheries of the Department of Interior are conducting a long-range radiological study of the estuarial waters in the Savannah River system near Savannah, Georgia. Also participating in the study are the Coast Guard, U.S. Treasury Department, and the Corps of Engineers, U.S. Army.

The purpose of the study is to trace the routes of radionuclides in a marine environment from their source to possible human consumption via the "food web" and to study factors affecting the uptake or reconcentration of these nuclides by various forms of marine life.

The Savannah River estuary was selected for study since it represents one of the best estuaries in the United States suitable for radiological studies. The Savannah River estuary is ideally suited for such studies because a limited amount of radioactive wastes from the nuclear operations at the Savannah River plant are discharged into the river, which flows 120 miles to the estuary. The Savannah River Plant is operated for the Atomic Energy Commission by the E. I. du Pont de Nemours Company.

The survey has been planned to progress under a three-phase program. Phase I is to be conducted exclusively in the Savannah River estuary with initial sampling being conducted on a monthly, and later probably on a seasonal or quarterly basis.

Phase II will be conducted in the estuary and upstream on the Savannah River in the fresh waters which are out of the tidal intrusion area. Studies will include such items as sediment size as a function of activity and activity distributions in the river.

Phase III will be carried on for studying the over-all problem with particular emphasis on the inclusion of radionuclides into the food chain. Phases II and III are planned to be conducted concurrently with Phase I, and the project is scheduled for completion during the latter part of fiscal year 1963.

At present, Phase I is underway and it generally consists of monthly and seasonal collections of water and silt samples, shrimp and crabs, oysters, minnows and other types of fish life, together with marine plants. Samples collected to date have been sent to the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Alabama, where analyses for specific radioactive substances such as strontium-90 have been conducted. The Fish and Wildlife Service of the Bureau of Commercial Fisheries, Department of the Interior, is performing the specialized analyses of the marine organisms. The U.S. Coast Guard is providing ships and crews for carrying out the marine sampling program at the mouth of the Savannah River.

Samples for the initial phase of this radiological survey are being taken from the stations shown in figure 1. The graphs shown in figures 2 and 3 display the analytical results for the samples collected during the first four months of thes urvey. In addition to these results, figure 2 comparatively depicts the April 1952 data which were taken from the *Interim Report on the Savannah River Study, July 1951–June 1952,* issued by the Public Health Service, Department of Health, Education, and Welfare. This data was taken upstream of the tidal intrusion.

Control samples are being collected from the coastal waters of South Carolina at Edisto Beach and Beaufort. These control areas lie some 30 miles north of the Savannah River Estuary. The tidal currents along the South Carolina and Georgia coasts usually flow in a general southerly direction from the control areas towards the Savannah River Estuary. Therefore, it is felt that since the tidal currents are generally flowing away from the control areas, marine samples in the control areas would probably be unaffected by limited radioactive wastes discharged to the Savannah River.

The analytical results acquired to date from this surveillance program were reduced to average values. The average value for each sample analyzed was calculated by weighting with the size of the sample. However, those samples that were less than the minimum level of detectability were assigned a value of one-half of that level.

Due to the short four-month period of sampling and the small number of samples collected, the present data from this surveillance operation are considered to be insufficient for making definite conclusions. It is felt that continued sampling with the resulting increase in analytical results will yield definite conclusions concerning the base line background radiation levels of the Savannah River Estuary.

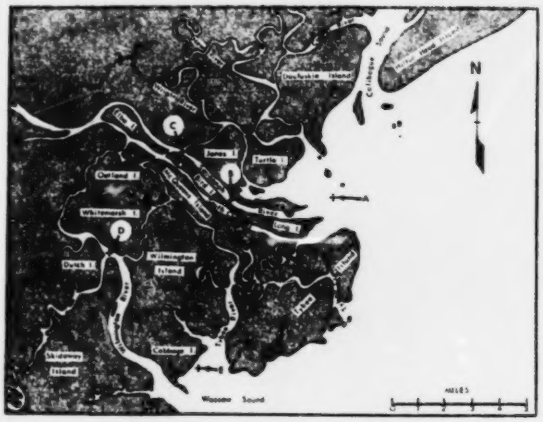

FIGURE 1.—SAVANNAH ESTUARY ENVIRONMENTAL RADIOLOGICAL SURVEY SAMPLING LOCATIONS

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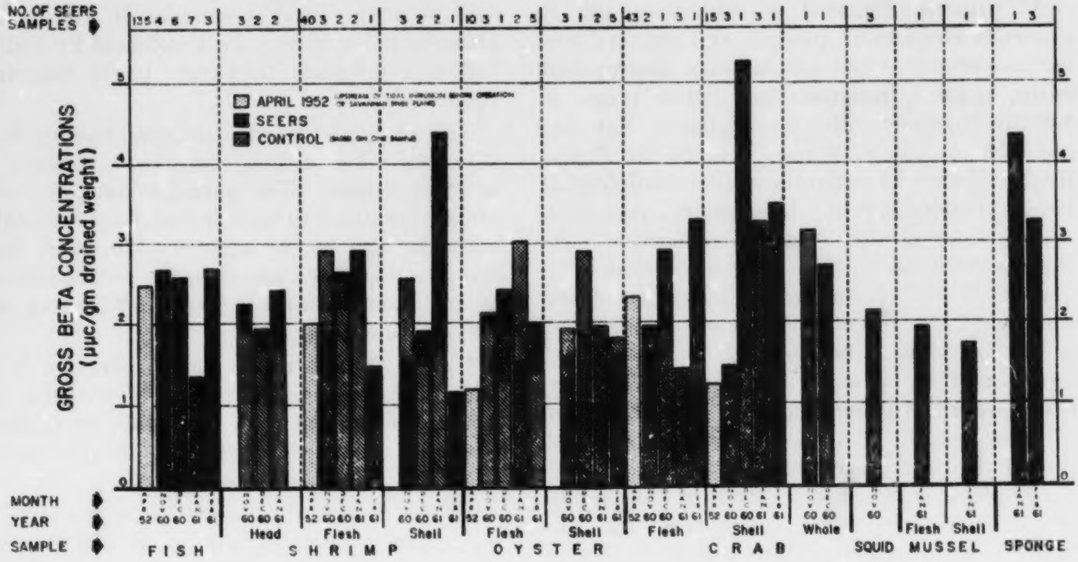

FIGURE 2.—GROSS BETA ACTIVITY, SAVANNAH ESTUARY BIOTA AND CONTROLS, BY SAMPLING PERIODS—APRIL 1952, NOVEMBER, DECEMBER 1960, JANUARY, FEBRUARY 1961

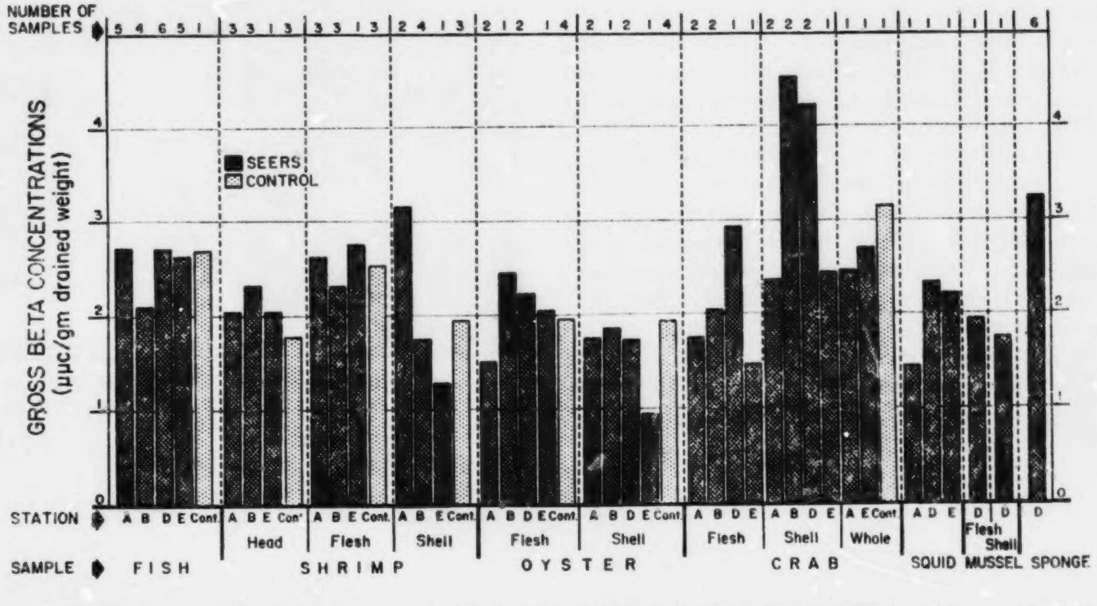

FIGURE 3.—GROSS BETA ACTIVITY, SAVANNAH ESTUARY BIOTA AND CONTROLS, BY SAMPLING STATIONS FOR NOVEMBER 1960–FEBRUARY 1961

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Announced Russian Nuclear Detonations

On September 1, 1961 the Union of Soviet Socialist Republics resumed nuclear weapons testing in the atmosphere. They have utilized three test sites, the locations of which have the following geographic coordinates:

Semiplatinsk	52° N 78° E
Novaya-Semlya	75° N 55° E
East of Stalingrad	Not available

The following table presents the date, location and approximate size of the announced detonations through October 3, 1961.

Test Number	Location	Date	Size
1	Semiplatinsk	September 1, 1961	Intermediate kiloton range.
2	Semiplatinsk	September 4, 1961	Low kiloton range.
3	Semiplatinsk	September 5, 1961	Low-intermediate kiloton range.
4	East of Stalingrad	September 6, 1961	Low-intermediate kiloton range.
5	Novaya-Semlya	September 10, 1961	Several megaton range.
6	Novaya-Semlya	September 10, 1961	Low-intermediate kiloton range.
7	Novaya-Semlya	September 12, 1961	Several megaton range.
8	Semiplatinsk	September 13, 1961	Low-intermediate kiloton range.
9	Novaya-Semlya	September 13, 1961	Low-intermediate kiloton range.
10	Novaya-Semlya	September 14, 1961	Several megaton range.
11	Novaya-Semlya	September 16, 1961	Order of a megaton.
12	Semiplatinsk	September 17, 1961	Intermediate kiloton range.
13	Novaya-Semlya	September 18, 1961	Order of a megaton.
14	Novaya-Semlya	September 20, 1961	Order of a megaton.
15	Novaya-Semlya	September 22, 1961	Order of a megaton.
16	Novaya-Semlya	October 2, 1961	Order of a megaton.

Radiation Surveillance Measurements

There are several measurements that may be used to measure radiation levels in our environment. Each type of measurement provides a different kind of information and the type will be dependent on the degree of sophistication desired. In some cases, there may be a timelag for an isotope to appear in a medium. For instance, while there may be a certain percentage of iodine-131 in the surface air, it must be ingested by cows directly or enter plants through the root system for later ingestion before it can appear in the milk. Because of the conditions of some detonations, isotopes such as strontium-90 may not be deposited on the earth's surface for several months.

Gross Beta Determinations

Gross beta measurements may be determined on air, water, soil, or any desired media. As the name implies, this determination measures only the beta radioactivity without regard to the elements or isotopes emitting the radiation. Therefore, it is very difficult to interpret from beta measurements specific internal doses to the individual inhaling or ingesting the material.

Gross beta measurements are valuable, however, to determine the arrival of fallout and the concentration in the air mass. The filters may be used to determine the age of the fallout particles by measuring the rate of decay, and also for gamma spectroscopy to determine qualitatively the specific gamma emitting isotopes present on the filter.

To make measurements of the gross beta radiation in air, large volumes must be drawn through a filter to trap the particulates from the air. After a period of time which allows for the natural radioactivity to decay, the filter is counted in the laboratory to determine the amount of fission product activity. A field determination using a geiger counter may also be used to provide a rough quantitative answer. The result is usually expressed as micromicrocurie per cubic meter of air ($\mu\mu c/m^3$). The fact that there is beta activity in the air does not necessarily indicate that fallout particles have been deposited on the ground. The particles are airborne and hence the concentration and the length of time the concentration exists at any one place is highly dependent on meteorological conditions.

Isotopic Analyses

It is necessary to conduct isotopic analyses to determine the quantity of each isotope present in a sample to aid in the evaluation of the radiation dose to persons. The sample may be an air filter, soil, water, food, or milk. Gamma spectroscopy is used to determine the gamma emitting isotopes. Radiochemistry is usually necessary to identify isotopes, such as strontium-90, that are pure beta emittors.

External Gamma Measurements

External gamma radiation emanates from fallout particles that are deposited on the earth's surface. It is usually measured by a geiger counter held three feet above the ground. It is a measure of whole body exposure when a person remains at the same location for a given time and is generally expressed as milliroentgens per hour, or roentgen per hour (r/hr).

This type of measurement is not intended to assess levels of radioactivity in air, therefore, cannot be used to estimate such radioactivity concentrations. It is useful in measuring deposited radioactivity from fallout in situations which have shown air levels in excess of 100,000 $\mu\mu c/m^3$ or where precipitation has hastened the ground deposition of airborne fallout debris.

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SECTION I. — AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. During the period reported, it consisted of 45 stations at urban locations (see figure 1) operated by State and local health department personnel with 2 of the stations operated by Public Health Service personnel. The Network was expanded in September, following the resumption of nuclear weapons testing.

Measurements of gross beta radioactivity in air are taken as they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The station located at Atlanta, Georgia, conducts its own laboratory analyses.

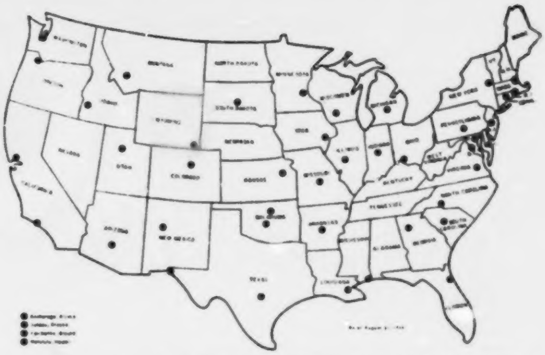

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

Air samplers were in operation at the 45 stations on an average of 70 percent of the week. Air is drawn through a cellulose carbon-loaded dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are absorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples.

Values for June and July 1961 as presented in tables 1 and 2 are generally below limits of detection by present instrumentation.

Due to the resumption of nuclear weapons testing, a renewed interest in the results of the

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR, JUNE 1961 GROSS BETA DETERMINATIONS

Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)	Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)
City	State					City	State				
Anchorage	Alaska	21	0.12	<0.10	<0.10	Minneapolis	Minnesota	9	0.21	<0.10	<0.16
Fairbanks	Alaska	14	0.14	<0.10	<0.10	Pascagoula	Mississippi	18	0.22	<0.10	<0.12
Juneau	Alaska	22	0.16	<0.10	<0.10	Jefferson City	Missouri	20	0.23	<0.10	<0.15
Phoenix	Arizona	5	<0.10	<0.10	<0.10	Helena	Montana	22	0.32	<0.10	<0.16
Little Rock	Arkansas	20	0.25	<0.10	<0.15	Trenton	New Jersey	15	0.28	<0.10	<0.15
Berkeley	California	22	0.12	<0.10	<0.10	Santa Fe	New Mexico	18	0.27	<0.10	<0.17
Los Angeles	California	20	0.14	<0.10	<0.10	Albany	New York	29	0.27	<0.10	<0.14
Denver	Colorado	6	0.17	0.10	0.07	Gastonia	North Carolina	22	0.28	<0.10	<0.16
Hartford	Connecticut	31	0.25	<0.10	<0.14	Oklahoma City	Oklahoma	17	0.46	<0.10	<0.16
Washington	District of Columbia	20	0.54	<0.10	<0.19	Ponca City	Oklahoma	29	0.16	<0.10	<0.10
Jacksonville	Florida	20	0.24	<0.10	<0.14	Portland	Oregon	21	0.32	<0.10	<0.14
Atlanta	Georgia	14	0.21	<0.10	<0.12	Harrisburg	Pennsylvania	22	0.23	<0.10	<0.14
Honolulu	Hawaii	21	<0.10	<0.10	<0.10	Providence	Rhode Island	22	0.29	<0.10	<0.17
Boise	Idaho	9	0.39	0.15	0.24	Columbia	South Carolina	7	0.20	<0.10	<0.13
Springfield	Illinois	6	0.25	0.11	0.17	Pierre	South Dakota	5	0.44	0.13	0.23
Indianapolis	Indiana	28	0.31	<0.10	<0.15	Austin	Texas	21	0.26	<0.10	<0.11
Iowa City	Iowa	22	0.26	<0.10	<0.16	El Paso	Texas	17	0.39	<0.10	<0.19
Topeka	Kansas	22	0.22	<0.10	<0.13	Salt Lake City	Utah	30	0.19	<0.10	<0.11
New Orleans	Louisiana	3	0.18	<0.10	<0.14	Richmond	Virginia	22	0.22	<0.10	<0.13
Baltimore	Maryland	22	0.28	<0.10	<0.18	Seattle	Washington	22	0.15	<0.10	<0.10
Lawrence	Massachusetts	20	0.20	<0.10	<0.13	Madison	Wisconsin	22	0.24	<0.10	<0.13
Lansing	Michigan	13	0.25	<0.10	<0.15	Cheyenne	Wyoming	8	0.18	<0.10	<0.14

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—RADIOACTIVITY OF PARTICULATES IN AIR, JULY 1961 GROSS BETA DETERMINATIONS

Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)	Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)
City	State					City	State				
Anchorage	Alaska	20	<0.10	<0.10	<0.10	Minneapolis	Minnesota	8	0.13	<0.10	<0.11
Fairbanks	Alaska	19	0.14	<0.10	<0.10	Pascagoula	Mississippi	13	0.73	<0.10	<0.23
Juneau	Alaska	15	0.13	<0.10	<0.10	Jefferson City	Missouri	19	0.13	<0.10	<0.10
Phoenix	Arizona	7	<0.10	<0.10	<0.10	Helena	Montana	19	0.17	<0.10	<0.12
Little Rock	Arkansas	18	0.11	<0.10	<0.10	Trenton	New Jersey	9	0.39	<0.10	<0.15
Berkeley	California	21	0.32	<0.10	<0.13	Santa Fe	New Mexico	16	0.17	<0.10	<0.11
Los Angeles	California	15	<0.10	<0.10	<0.10	Albany	New York	31	0.18	<0.10	<0.11
Denver	Colorado	3	0.11	<0.10	<0.10	Gastonia	North Carolina	20	0.52	<0.10	<0.15
Hartford	Connecticut	28	0.17	<0.10	<0.11	Oklahoma City	Oklahoma	16	0.16	<0.10	<0.11
Washington	District of Columbia	25	0.27	<0.10	<0.13	Ponca City	Oklahoma	31	0.18	<0.10	<0.10
Jacksonville	Florida	17	<0.10	<0.10	<0.10	Portland	Oregon	20	0.11	<0.19	<0.10
Atlanta	Georgia	15	0.11	<0.10	<0.10	Harrisburg	Pennsylvania	15	0.13	<0.10	<0.11
Honolulu	Hawai	20	<0.10	<0.10	<0.10	Providence	Rhode Island	20	0.28	<0.10	<0.13
Boise	Idaho	7	0.20	<0.10	<0.15	Columbia	South Carolina	6	<0.10	<0.10	<0.10
Springfield	Illinois	9	0.14	<0.10	<0.11	Pierre	South Dakota	8	0.27	<0.10	<0.15
Indianapolis	Indiana	30	0.22	<0.10	<0.12	Austin	Texas	20	0.36	<0.10	<0.13
Iowa City	Iowa	19	0.20	<0.10	<0.12	El Paso	Texas	16	0.17	<0.10	<0.11
Topeka	Kansas	21	0.29	<0.10	<0.11	Salt Lake City	Utah	29	0.14	<0.10	<0.11
New Orleans	Louisiana	3	0.15	<0.10	<0.11	Richmond	Virginia	19	0.39	<0.10	<0.12
Baltimore	Maryland	20	0.21	<0.10	<0.12	Seattle	Washington	20	<0.10	<0.10	<0.10
Lawrence	Massachusetts	19	0.35	<0.10	<0.13	Madison	Wisconsin	24	0.13	<0.10	<0.10
Lansing	Michigan	0	—	—	—	Cheyenne	Wyoming	9	0.12	<0.10	<0.10

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

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TABLE 3.—DAILY MEASUREMENTS OF FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR AT SELECTED STATIONS, SEPTEMBER 19-30, 1961

[Concentrations in μμc/m³]

Station location	September											
	19	20	21	22	23	24	25	26	27	28	29	30
Anchorage, Alaska	1.14 [a] (6)	1.19 (7)	3.36 (15)	6.23 (20)	1.89 (11)	0.69 (17)	0.83 (12)	0.95 (14)	0.75	6.03 (13)	2.97 (15)	3.12 (20)
Los Angeles, Calif.	0.93 (9)	0.71 (21)	0.96 (19)	3.66 (19)	6.62 (9)	1.68	5.79 (15)	3.56 (17)	4.47 (16)	5.65 (16)	5.80 (19)	4.54 (17)
Washington, D. C.	39.02 (7)	17.16 (11)	2.79 (17)	50.25 (7)	41.88 (15)	10.78 (15)	5.84 (21)	2.36 (16)	2.75 (19)	4.57 (16)	6.58 (17)	12.25 (17)
Jacksonville, Fla.	113.21 (9)	2.22 (6)	1.74 (14)	9.75 (14)	33.39 (16)	35.64 (16)	28.32 (18)	16.42 (20)	8.42 (16)	6.86 (20)	8.78 (17)	2.49 (20)
Springfield, Ill.	59.94 (8)	100.64 (11)	296.30 (14)	60.61 (15)	4.26 (17)	1.37 (16)	<0.1	7.42 (17)	7.60 (19)	6.76 (18)	10.55 (16)	6.87 (9)
Topeka, Kans.	64.49 (7)	302.33 (11)	280.85 (15)	8.21 (18)	1.96 (24)	0.20	3.61 (20)	5.45 (19)	6.11 (18)	6.14 (13)	3.29 (21)	2.72 (21)
Lansing, Mich.	20.85	79.47 (11)	8.61 (17)	166.78 (8)	11.37 (17)	1.64 (19)	0.65 (30)	2.82 (13)	8.28 (19)	6.32 (15)	13.60 (19)	15.91 (23)
Minneapolis, Minn.	31.43 (16)	131.58 (11)	365.00 (14)	3.47 (16)	1.26 (12)	13.37 (17)	10.00 (19)	3.00 (19)	3.65 (18)	7.85 (15)	9.74 (17)	4.89 (16)
Albany, N. Y.	11.96 (7)	21.45 (11)	28.41 (13)	81.72 (13)	40.65 (15)	14.98 (17)	6.93 (26)	1.10 (17)	3.53 (16)	6.91 (15)	9.55 (16)	7.15 (17)
Gastonia, N. C.	28.99 (7)	3.99 (9)	1.48 (16)	56.55 (14)	23.44 (15)	7.16 (15)	3.44 (18)	3.31 (17)	3.15 (18)	9.60 (18)	6.85 (18)	7.5 (15)
Austin, Tex.	140.00 (8)	155.00 (11)	11.44 (17)	1.26 (20)	0.38	0.45 (27)	1.00 (16)	1.08 (25)	6.06 (19)	7.98 (16)	6.50 (20)	4.42 (20)
Salt Lake City, Utah	0.81 (7)	1.40 (13)	11.09 (18)	5.05 (16)	4.66 (17)	5.81 (18)	6.19 (17)	8.42	13.85 (17)	10.12 (12)	7.03 (17)	24.75 (15)
Seattle, Wash.	0.22	0.52 (20)	0.60 (17)	0.31	0.30	0.99 (19)	3.68 (14)	4.18 (17)	4.67 (17)	2.02 (21)	1.34 (13)	1.50 (19)

[a] Parenthesis denotes age of fission products in days.

Radiation Surveillance Network has been evidenced. Field measurements of gross beta determinations from stations showing increased readings have been released by the Public Health Service and published almost daily by newspapers. Table 3 presents confirmed daily laboratory results for September 19-30 for stations selected to provide geographical coverage.

Iso-concentration maps based on laboratory results of fission product gross beta concentrations in surface air are presented in figure 2 for the period September 16 through September 27, 1961. A chronological comparison of these maps show that while the levels in some sections of the United States exceed 500 μμc/m³, the air masses did not remain stationary in any one location. Because of this transitory nature of the contaminated air, the resultant inhalation hazard is extremely small.

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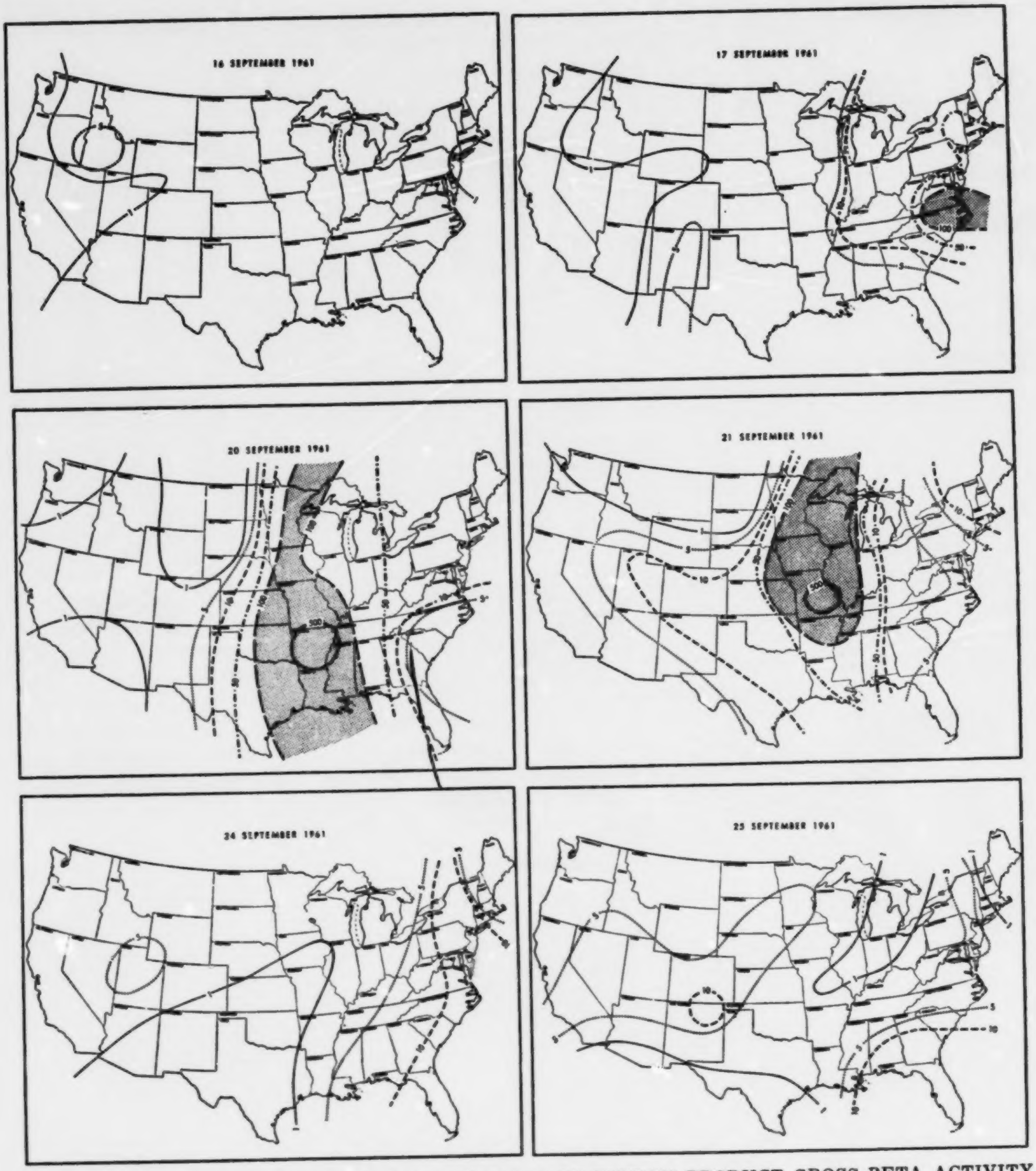
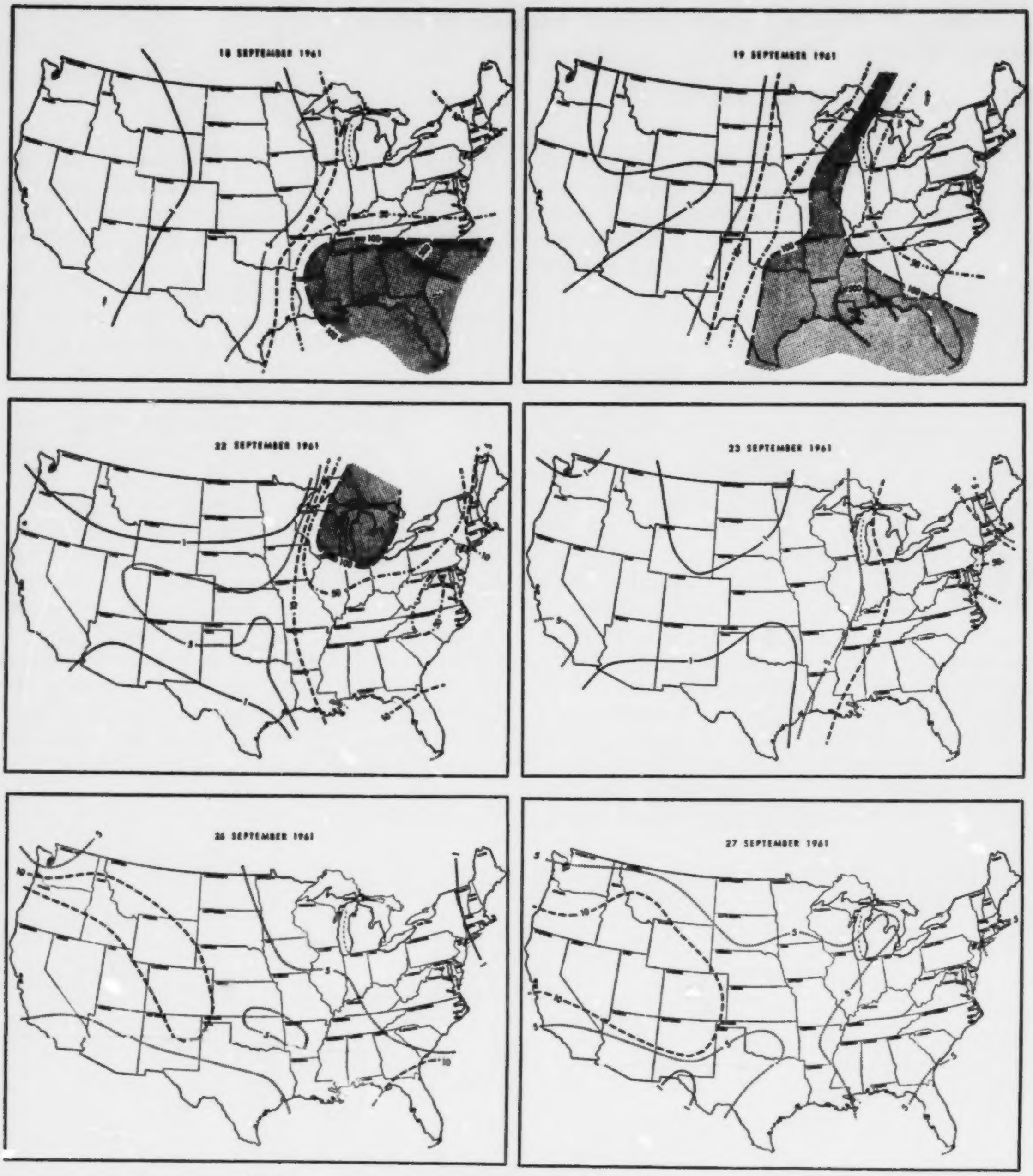

16 SEPTEMBER 1961
17 SEPTEMBER 1961
20 SEPTEMBER 1961
21 SEPTEMBER 1961
24 SEPTEMBER 1961
25 SEPTEMBER 1961
500
100
10
5

FIGURE 2.—DAILY ISO-CONCENTRATION CONTOURS OF FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR

(Concentration in $\mu\mu c/m^3$)

59-



18 SEPTEMBER 1961

19 SEPTEMBER 1961

22 SEPTEMBER 1961

23 SEPTEMBER 1961

26 SEPTEMBER 1961

27 SEPTEMBER 1961

FIGURE 2.—DAILY ISO-CONCENTRATION CONTOURS OF FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR—Continued

(Concentration in $\mu\mu c/m^3$)

60<

Surface Air Radon, Thoron, and Fission Product Gross Beta Concentrations At Cincinnati, Ohio

Robert A. Taft Sanitary Engineering Center, Public Health Service

Natural background radioactivity in our atmosphere is an important public health consideration because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially produced radionuclides. Natural radioactivity in surface air is attributed to a number of unstable nuclides other than those produced by man. The earth's crust contains trace amounts of uranium and thorium that occur naturally and which decay through a series of their daughter products. These decay products of uranium and thorium are introduced into surface air through their rare gas daughters, radon (radon-222) and thoron (radon-220), which in turn continue to decay through the uranium and thorium series, respectively. The radon and thoron content of air depends on the escape of these rare radioactive gases from the earth. Concentrations depend on prevailing atmospheric conditions such as ambient temperature, humidity, and pressure, and on soil conditions such as moisture, porosity and temperature.

Most of the natural radioactivity in surface air is due to radon (Rn^{222}) and its daughters. Thoron (Rn^{220}) and its daughters contribute much less because of thoron's short half-life and hence, a lower diffusion rate from the soil.

The Radiological Health Research Activities, Research Branch, Division of Radiological Health, Public Health Service, performs a continuous daily sampling program for radon (Rn^{222}), thoron (Rn^{220}), and gross beta fission product concentrations in surface air. The gross beta activity of atmospheric particulates, when measured several days after sample collection, is principally due to artificially produced radionuclides.

Radon-222 concentrations are determined from alpha measurements made immediately after the sampling period (24 to 72 hours) has ceased. Reported radon-222 (a.m.) concentrations have been corrected for any radon-220 daughter interferences. Radon-222 (p.m.) concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. These values are from the same filters that are counted at 8 a.m. the following day. Reported radon-222 (p.m.) concentrations are uncorrected for any radon-220

TABLE 1.—SURFACE AIR RADON (Rn^{222}), THORON (Rn^{220}), AND FISSION PRODUCT GROSS BETA CONCENTRATIONS, JUNE 19–JULY 14, 1961

End of sampling period	Continuous sample collection			Rn^{222} 8 a.m. ($\mu\mu c/m^3$)	Rn^{222} 3 p.m. ($\mu\mu c/m^3$)	Rn^{220} ($\mu\mu c/m^3$)	Beta activity ($\mu\mu c/m^3$)
	Sample change time	Sample period (hours)	Volume (m^3)				
June 19	0807	72.1	83.8	580	120	[illegible]	0.11
20	0803	23.9	28.4	[illegible]	120	3.9	0.24
21	0804	24.0	28.5	300	180	3.2	0.12
22	0813	24.1	28.5	550	100	7.2	0.13
23	0808	23.9	28.3	220	70	2.4	0.12
26	0805	71.9	85.3	800	100	8.6	0.10
27	0807	24.0	28.8	760	120	8.0	0.13
28	0805	23.9	28.3	810	130	9.0	0.16
29	0808	24.0	28.5	1040	160	10.9	0.23
30	0812	24.0	28.6	890	140	10.6	0.19
July 3	0815	72.0	83.9	330	100	4.2	0.25
5	0810	47.9	56.4	240	200	4.1	0.11
6	0812	24.0	28.7	240	160	1.8	0.09
7	0808	23.9	28.5	680	90	2.9	0.07
10	0809	72.0	83.8		120		0.09
11	0804	23.9	28.7	800	100	8.2	0.11
12	0816	24.1	28.7	710	270	7.1	0.13
13	0823	24.1	28.4	410	120	3.0	0.04
14	0814	23.8	28.7	370	70	2.0	0.03
Average				510	130	5.9	0.13
Range of counting errors (twice standard deviations)							
Maximum				60	30	1.1	0.05
Minimum				30	15	0.5	0.01

TABLE 2.—SURFACE AIR RADON (Rn^{222}), THORON (Rn^{220}), AND FISSION PRODUCT GROSS BETA CONCENTRATIONS, JULY 17–AUGUST 11, 1961

End of sampling period		Continuous sample collection			Rn^{222} 8 a.m. (μμc/m³)	Rn^{222} 3 p.m. (μμc/m³)	Rn^{220} (μμc/m³)	Beta activity (μμc/m³)
		Sample change time	Sample period (hours)	Volume (m³)				
July	17	0803	71.8	86.8	230	110	1.9	0.02
	18	0811	24.1	29.5	640	120	3.4	0.07
	19	0815	24.0	29.1	210	110	1.4	0.10
	20	0807	23.8	[illegible]	460	100	3.8	0.02
	21	0806	23.9	[illegible]	420	110	2.3	0.04
	24	0808	72.0	86.9	260	90	3.0	0.04
	25	0807	23.9	29.3	170	140	1.1	<0.01
	26	0810	24.0	29.5	540	120	3.1	<0.01
	27	0823	24.2	29.2	750	120	4.8	<0.01
	28	0803	23.6	28.9	550	170	5.7	0.06
	31	0803	72.0	86.7	320	150	2.4	0.04
August	1	0825	24.4	29.7	350	120	2.4	0.06
	2	0808	23.7	28.6	440	120	2.3	0.01
	3	0811	24.0	28.6	250	130	1.3	0.09
	4	0807	23.9	28.7	700	100	3.6	0.10
	7	0816	72.1	84.0	800	160	5.9	0.06
	8	0810	23.9	28.7	890	150	6.3	0.13
	9	0810	24.0	28.7	740	100	6.6	0.13
	10	0804	23.9	29.0	360	110	2.8	0.12
	11	0810	24.1	29.3	160	170	1.7	0.07
Average					460	125	3.3	0.05
Range of counting errors (twice standard deviations)								
Maximum					50	20	0.9	0.04
Minimum					20	17	0.4	0.01

daughter interferences. Radon-220 concentrations are determined from alpha measurements made on the sample used to evaluate the corrected radon-222 (a.m.) concentrations, but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder.

There has been a recent change in the reporting period because the data are now computed by an electronic data processing system which is programmed for thirteen four-week periods per calendar year. The data for the periods June 19-July 14, and July 17-August 11, 1961 appear in tables 1 and 2.

REFERENCE

Setter, L. R. and Coats, G. I., "The Determination of Airborne Radioactivity," *American Industrial Hygiene Association Journal*, Vol. 22, No. 1, Feb. 1961.

Radioactivity Measurements In Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during June 1961 is presented in table 1, and the radioactivity profile for the same month and the first and second quarters of 1961 are shown in figure 1. This figure illustrates the data plotted in semilogarithmic coordinates. The abscissa is expressed in micromicrocuries per cubic meter of surface air. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

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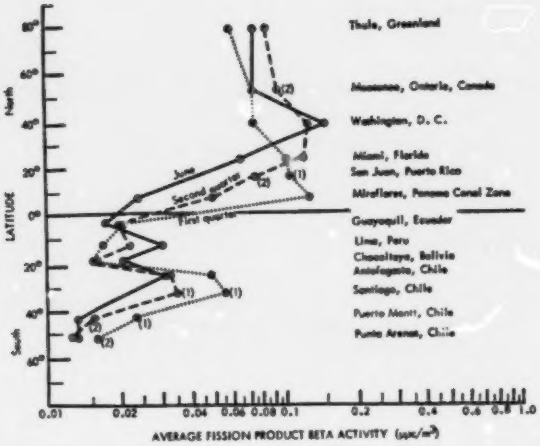

(1) Average based on one month.

(2) Average based on two months.

FIGURE 1.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST), FIRST QUARTER, SECOND QUARTER, AND JUNE 1961

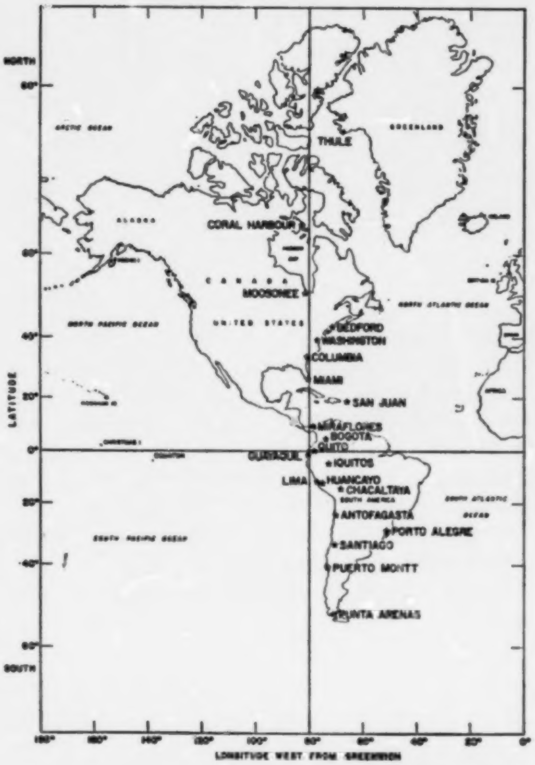
NORTH
80°
60°
40°
20°
0°
20°
40°
60°
SOUTH
LATITUDE
ARCTIC OCEAN
GREENLAND
THULE
ALASKA
CORAL HARBOUR
CANADA
MOOSONEE
UNITED STATES
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
BEDFORD
WASHINGTON
COLUMBIA
MIAMI
SAN JUAN
MIRAFLORES
BOGOTA
QUITO
GUAYAQUIL
IQUITOS
LIMA
HUANCAYO
CHACALTAYA
SOUTH AMERICA
SOUTH ATLANTIC OCEAN
ANTOFAGASTA
PORTO ALEGRE
SANTIAGO
PUERTO MONTT
PUNTA ARENAS
SOUTH PACIFIC OCEAN
180°
160°
140°
120°
100°
80°
60°
40°
20°
0°
LONGITUDE WEST FROM GREENWICH

FIGURE 2.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST) (From NRL Report 5359, September 1959)

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TABLE 1.—DAILY RECORD OF FISSION PRODUCT BETA ACTIVITY COLLECTED BY AIR FILTRATION, JUNE 1961

[Disintegrations/minute per cubic meter]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	Mauna Loa, Hawaii	Miami, Florida	Washington, D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1	0.04	0.05	0.07	0.09	0.07	----------	0.01	0.19	0.40	0.65	0.18	0.14
2	0.04	0.05	0.07	0.09	0.07	----------	0.01	0.19	0.40	0.65	0.18	0.14
3	0.02	0.05	0.02	0.06	0.06	----------	0.04	0.19	0.14	0.29	0.18	0.14
4	0.02	0.02	0.02	0.06	0.06	----------	0.04	0.19	0.14	0.29	0.18	0.14
5	0.02	0.02	0.02	0.06	0.06	----------	0.04	0.19	0.14	0.29	0.18	0.14
6	0.03	0.07	0.05	0.04	0.07	----------	0.08	0.16	0.14	0.39	0.17	0.17
7	0.03	0.07	0.05	0.04	0.07	0.05	0.08	0.16	0.32	0.39	0.17	0.17
8	0.03	0.03	0.04	0.04	0.03	0.05	0.03	0.19	0.13	0.29	0.17	0.25
9	0.03	0.03	0.04	0.04	0.03	0.05	0.03	0.19	0.13	0.29	0.17	0.25
10	----------	0.03	0.03	0.04	0.04	0.02	0.01	0.12	0.07	0.15	0.17	0.29
11	----------	0.03	0.03	0.04	0.04	0.02	0.01	0.12	0.07	0.15	0.17	0.29
12	----------	0.03	0.03	0.04	0.04	0.02	0.01	0.12	0.07	0.15	0.17	0.29
13	----------	0.04	0.06	----------	0.06	----------	0.02	0.26	0.11	0.22	0.15	0.39
14	----------	0.04	0.06	----------	0.06	----------	0.02	0.26	0.11	0.22	0.15	0.39
15	----------	0.01	0.09	----------	0.07	----------	0.06	0.12	0.11	0.23	0.15	0.35
16	----------	0.01	0.09	----------	0.07	----------	0.06	0.12	0.11	0.23	0.15	0.35
17	----------	0.02	0.09	----------	0.06	----------	0.06	0.22	0.12	0.41	0.15	0.28
18	----------	0.02	0.09	----------	0.06	----------	0.06	0.22	0.12	0.41	0.15	0.28
19	----------	0.02	0.09	0.03	0.06	0.04	0.06	0.22	0.12	0.41	0.15	0.28
20	----------	0.03	0.09	0.03	0.10	0.04	0.14	0.10	0.19	0.60	0.14	0.04
21	----------	0.03	0.09	0.03	0.10	0.04	0.14	0.10	0.19	0.60	0.14	0.04
22	----------	0.02	0.21	0.03	0.06	0.04	0.04	0.15	0.12	0.17	0.14	0.05
23	----------	0.02	0.21	0.03	0.06	0.04	0.04	0.15	0.12	0.17	0.14	0.05
24	----------	0.02	0.05	0.03	0.08	----------	0.04	0.36	0.11	0.41	0.14	0.03
25	----------	0.02	0.05	0.03	0.08	----------	0.04	0.36	0.11	0.41	0.14	0.03
26	----------	0.02	0.05	0.03	0.08	----------	0.04	0.36	0.11	0.41	0.14	0.03
27	----------	0.01	0.10	----------	0.06	----------	0.07	0.21	0.07	0.17	0.18	0.02
28	----------	0.01	0.10	----------	0.06	----------	0.07	0.21	0.07	0.17	0.18	0.02
29	----------	0.02	0.05	----------	0.10	----------	0.08	0.16	0.07	0.32	0.18	0.02
30	----------	0.02	0.05	----------	0.10	----------	0.08	0.16	0.07	0.32	0.18	0.02
Mean (dpm/m³)	0.029	0.029	0.069	0.044	0.065	0.037	0.050	0.192	0.139	0.329	0.161	0.169
Mean (μμc/m³)	0.013	0.013	0.031	0.020	0.029	0.017	0.023	0.086	0.063	0.148	0.073	0.076

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SECTION II. — MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There are two Public Health Service Milk Monitoring Programs. The original network consisted of five milkshed sampling stations. It was later expanded to twelve stations, nine of which are still active. Raw milk is spot sampled at these stations. During 1960 a processed milk sampling program of 60 stations was established. Since the sampling procedures for the raw milk sampling stations and the processed milk area sampling stations are different, they are described and reported saparately. The Public Health Service Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, continues to conduct the analyses for the original network stations; the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Alabama, and the Southwestern Radiological Health Laboratory at Las Vegas, Nevada, provide analytical services for the new program.

The objectives of the two sampling programs are not the same. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program more directly related to the milk consumed by the population was necessary. The Public Health Service, Department of Health, Education, and Welfare, acted to provide facilities for this change. This resulted in the transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality.

In some instances, the newly designated stations are the same as those which were reported originally. The establishment of the new processed milk area sampling stations does not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It is important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of a comparative study.

Because of the different sources of these samples, changes in the method of collecting samples, and the utilization of different laboratory techniques, differences were anticipated in the amounts of radioactivity in the milk under the two programs. For this reason, an investigation to determine the comparability of the two programs was begun in January 1961. This investigation covers many factors including laboratory methodology and collection methods. Until this study has been completed, and additional experience has been gained under the new program, no valid interpretation can be made of any differences of

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radioactivity in milk samples collected under the two systems.

Publication of the data from each program will normally follow about four months after sample collection because of the time required for shipment, processing, decay product build-up, compilation of the data, and clearance and publication procedures.

Raw Milk Sampling Stations

The initial purpose of establishing this network was in keeping with the normal and continuing program of the Public Health Service to determine trends in our changing environment with respect to measuring the amounts of radioactivity in water, air, milk, and other foods. Milk was the food chosen for initial testing because it is among the most important components of the diet and is available at all seasons of the year and in all climates. A primary objective of the project was to develop effective collection systems and radiochemical analysis procedures which would make them more suitable for larger scale programs.

The criteria on which the selection of the original sampling stations was based appeared in the discussion sections of all Volume I issues of *Radiological Health Data.*

For the period reported, one-gallon raw milk samples were collected from a dairy company once each month and forwarded by air parcel post to the Robert A. Taft Sanitary Engineering Center for radionuclide analyses. These samples represent between 2,000- and 90,000-gallon lots. The concentration of iodine-131, barium-140, and cesium-137 are currently being measured by gamma scintillation spectroscopy. Total radiostrontium and strontium-90 are determined following radiochemical separations. The amount of strontium-90 is calculated by measuring the buildup of the strontium-90 daughter decay product, yttrium-90, over a two-week period. Measurements are made in a low background anticoincidence beta counter. The total radioactive strontium is counted in a shielded internal proportional counter. The difference between the total strontium and strontium-90 is reported as strontium-89. Stable calcium is also determined.

The April through September 1960 issues of *Radiological Health Data* list references for technical descriptions of analytical procedures.

Table 1 presents second quarter 1961 averages and the June 1961 data for the raw milk sampling stations.

Processed Milk Area Sampling Stations

The processed milk surveillance program will provide additional information on levels of radioactivity in milk consumed by the public. The new stations have been established in cooperation with State and local health and milk sanitation agencies. Each city has been selected to provide adequate coverage with respect to production areas and the consuming population. The emphases of this expanded sampling and radioassay program are:

1. to measure the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of parteurized and homogenized milk at the processing plant, and
2. to provide one sampling point within each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups.

The new network was designed to sample processed milk rather than the raw product. The sampling procedure was developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold.

The samples from the new stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southwestern or Southeastern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the Western States. Figure 1 shows the locations of these stations.

Radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140}, and I^{131} are performed. The values for Sr^{89}, Ba^{140}, and I^{131} during the second quarter 1961 were below the levels of detection by current instrumentation and are therefore not shown in table 2. The lower level of detection for Sr^{89} is 5 μμc/liter, and for Ba^{140}, and I^{131}, 10 μμc/liter. Other radionuclides of concern to public health agencies will be included for assay as necessary for a more complete monitoring of the milk supply.

Due to the resumption of nuclear weapons testing, a program of daily sampling for I^{131} analyses was initiated at selected stations in areas where the highest concentrations were anticipated. Table 3 presents daily laboratory results from the beginning of daily sampling on September 19 through October 10, 1961, for the stations selected. The latest possible results will continue to be published in future issues of *Radiological Health Data.*

TABLE 1.—RADIOACTIVITY IN MILK—RAW MILK SAMPLING STATIONS, SECOND QUARTER AND JUNE 1961

[Radioactivity concentrations in μμc/liter]

Area	Calcium (grams/liter)		Strontium-90		Cesium-137	
	Second quarter	June	Second quarter	June	Second quarter	June
Atlanta, Ga	1.18	1.19	13	13	25	25
Austin, Tex	1.16	1.15	3	3	10	10
Chicago, Ill	1.13	1.11	7	5	20	25
Cincinnati, Ohio	1.17	1.18	10	10	15	15
New York, N.Y	1.14	1.14	8	9	15	15
Sacramento, Calif	1.15	1.16	3	3	10	<5
Salt Lake City, Utah	1.16	1.14	3	4	10	20
Spokane, Wash	1.15	1.15	8	8	15	20
St. Louis, Mo	1.22	1.24	22	23	25	20
Network average	1.16	1.16	9	9	15	15

Note: I^{131}, Sr^{89}, and Ba^{140} are below minimum detectable limits for samples collected in June. These limits are 10 μμc/liter for I^{131} and Ba^{140} and 5 μμc/liter for Sr^{89}.

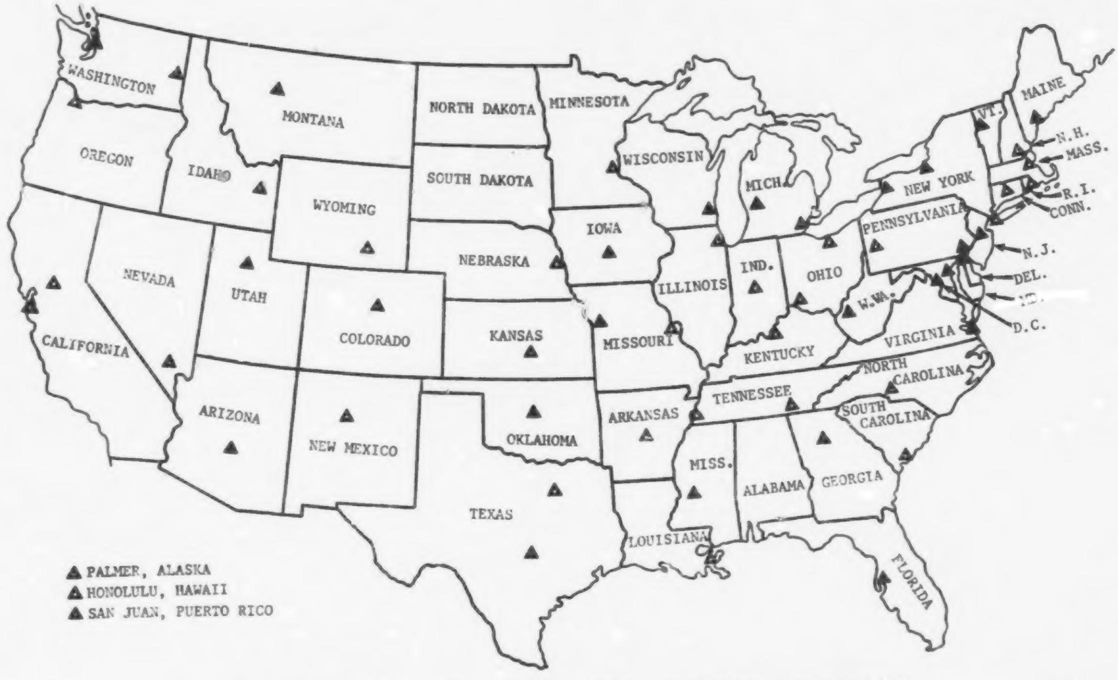
WASHINGTON
OREGON
CALIFORNIA
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICH.
IND.
OHIO
KENTUCKY
TENNESSEE
MISS.
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W.VA.
PENNSYLVANIA
NEW YORK
VT.
MAINE
N.H.
MASS.
R.I.
CONN.
N.J.
DEL.
MD.
D.C.
▲ PALMER, ALASKA
▲ HONOLULU, HAWAII
▲ SAN JUAN, PUERTO RICO

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

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TABLE 2.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, SECOND QUARTER AND JUNE 1961

[Radioactivity concentrations in μμc/liter]

Area	Calcium (grams/liter)		Strontium-90		Cesium-137	
	Second quarter	June	Second quarter	June	Second quarter	June
Albuquerque, N. Mex	1.06	1.16	5	8	5	10
Atlanta, Ga	1.29	1.40	10	10	20	30
Austin, Tex	1.24	1.26	3	3	5	10
Baltimore, Md	1.23	1.28	8	10	15	20
Boston, Mass	1.21	1.13	11	12	35	45
Buffalo, N.Y	1.22	1.24	8	8	15	20
Burlington, Vt	1.22	1.12	8	8	15	25
Charleston, S.C	1.25	1.24	12	11	25	40
Charleston, W. Va	1.20	1.20	9	11	15	20
Charlotte, N.C	1.26	1.22	12	8	15	30
Chattanooga, Tenn	1.33	1.28	11	10	15	20
Chicago, Ill	1.17	1.14	8	8	10	15
Cincinnati, Ohio	1.24	1.24	9	10	10	<5
Cleveland, Ohio	1.20	1.19	8	7	10	15
Dallas, Tex	1.24	1.26	9	8	10	10
Denver, Colo	1.01	1.02	6	7	5	15
Des Moines, Iowa	1.01	1.02	7	7	5	15
Detroit, Mich	1.17	1.18	8	7	1	20
Grand Rapids, Mich	1.25	1.23	7	8	15	25
Hartford, Conn	1.17	1.14	9	10	30	40
Helena, Mont	1.02	1.10	6	7	10	25
Honolulu, Hawaii	0.96	1.05	4	2	10	25
Idaho Falls, Idaho	1.04	1.11	5	5	10	25
Indianapolis, Ind	1.23	1.20	8	8	10	15
Jackson, Miss	1.35	1.32	14	13	15	15
Kansas City, Mo	[a] 1.08	1.16	[a] 12	13	[a] 15	20
Laramie, Wyo	1.00	1.01	5	6	10	20
Las Vegas, Nev	1.00	1.03	3	3	5	15
Little Rock, Ark	1.21	1.20	19	16	25	25
Louisville, Ky	1.18	1.13	11	10	10	20
Manchester, N.H	1.23	1.22	12	14	45	45
Memphis, Tenn	1.30	1.30	13	14	10	20
Milwaukee, Wis	1.19	1.16	6	6	20	25
Minneapolis, Minn	1.07	1.20	7	7	10	25
New Orleans, La	1.30	1.29	13	14	20	15
New York, N.Y	1.17	1.06	9	10	25	30
Norfolk, Va	1.26	1.22	9	10	20	25
Oklahoma City, Okla	1.22	1.21	8	8	5	15
Omaha, Nebr	1.07	1.08	6	7	10	20
Palmer, Alaska	1.03	1.03	9	8	5	15
Philadelphia, Pa	1.18	1.15	9	11	15	25
Phoenix, Ariz	0.97	1.01	5	6	5	15
Pittsburgh, Pa	1.27	1.22	12	12	20	30
Portland, Me	1.26	1.26	10	10	40	45
Portland, Oreg	1.05	1.06	12	15	30	50
Providence, R.I	1.17	1.19	10	12	40	60
Sacramento, Calif	1.05	1.10	5	6	<5	5
Salt Lake City, Utah	1.01	1.00	5	4	10	20
San Francisco, Calif	1.04	1.16	5	5	10	15
San Juan, P.R	1.23	1.24	4	4	5	10
Seattle, Wash	1.03	1.10	9	11	25	45
Spokane, Wash	1.02	1.00	8	10	15	25
St. Louis, Mo	1.09	1.22	8	10	20	30
Syracuse, N.Y	1.19	1.23	7	7	15	10
Tampa, Fla	1.23	1.20	6	6	110	130
Trenton, N.J	1.17	1.14	9	10	15	30
Washington, D.C	1.18	1.15	8	10	20	25
Wichita, Kans	1.01	1.04	8	10	10	15
Wilmington, Del	1.20	1.18	10	10	15	25
Average	1.16	1.16	8	9	15	25

[a] Average based on two months' samples because of inadvertent loss of sample.

TABLE 3.—DAILY IODINE-131 DETERMINATIONS—PROCESSED MILK AREA SAMPLING STATIONS, SEPTEMBER 19–OCTOBER 10, 1961

[Concentrations in μμc/liter]

Area	September											October									
	19	20	21	22	23	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10
Atlanta, Ga	----	<10	90	80	----	320	260	210	----	----	----	----	100	290	100	100	120	----	----	80	100
Austin, Tex	----	----	----	----	----	----	----	----	----	20	50	30	20	50	10	30	30	30	40	40	40
Charleston, S. C	----	55	130	270	220	200	----	----	----	----	----	----	130	----	----	60	80	110	----	70	60
Chicago, Ill	----	----	----	----	----	----	----	----	----	210	----	----	250	170	210	180	180	----	----	200	150
Denver, Colo	----	----	----	----	----	----	----	----	110	110	150	----	90	----	120	100	120	100	----	120	70
Des Moines, Iowa	----	----	----	----	----	----	----	----	----	----	----	----	450	----	----	----	----	----	----	----	----
Jackson, Miss	----	----	100	310	----	230	430	460	300	270	----	----	190	200	140	160	180	----	----	100	110
Milwaukee, Wis	----	----	----	----	----	----	----	----	----	----	----	190	190	130	130	180	210	180	190	160	140
Minneapolis, Minn	----	----	----	----	----	----	----	----	----	----	----	----	500	----	----	----	----	----	----	----	----
New Orleans, La	<10	<10	20	40	----	530	290	200	280	270	----	----	170	150	170	110	80	----	----	80	60
New York, N. Y	----	----	----	----	----	----	----	----	----	90	440	----	60	120	100	100	100	150	----	120	140
Omaha, Nebr	----	----	----	----	----	----	----	----	----	----	----	----	730	480	390	200	----	----	----	260	210
Palmer, Alaska	----	----	----	----	----	----	----	----	[a] 670	----	----	----	----	----	----	450	----	350	----	----	620
Pascagoula, Miss	----	----	----	----	----	----	----	----	----	400	----	----	190	180	170	150	170	----	----	120	130
Sacramento, Calif	----	----	----	----	----	----	----	----	----	15	<10	----	<10	<10	<10	<10	<10	<10	----	<10	<10
Salt Lake City, Utah	----	----	----	----	----	----	----	----	----	280	----	----	130	120	100	200	----	----	----	180	100
Seattle, Wash	----	----	----	----	----	----	----	----	----	10	----	40	----	100	----	120	120	130	----	100	80
St. Louis, Mo	----	80	120	310	450	420	450	500	420	400	330	----	270	----	230	290	250	----	----	160	150
Tampa, Fla	----	40	40	140	----	110	50	70	----	----	----	----	40	----	----	----	----	----	----	----	----
Washington, D. C	----	----	----	----	----	----	----	70	80	70	60	----	10	40	70	60	80	100	----	----	70
Wichita, Kans	----	----	----	----	----	----	----	----	----	----	----	----	220	----	230	200	100	130	180	130	----

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SECTION III. — WATER

National Water Quality Network

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network operates under the provision of Section 4 (c) of the Federal Water Pollution Control Act, which states " . . . The Secretary shall . . . collect and disseminate basic data . . . (relating) to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and Local agencies, and industrial organizations commenced operations in October 1957. At present, there are 90 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are on interstate, coastal, and International Boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of approximately 300 stations will be in operation. Radioactivity is not yet being reported for a few of the more recently established stations.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of the levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally-occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing for a period of three years, the beta activity in most raw waters generally has approached a level attributable solely to natural sources. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. Some exceptions to this are seen, notably in the data for the Columbia, Tennessee and Animas Rivers. The resumption of nuclear weapons testing in the atmosphere by the USSR is expected ultimately to again raise the level of radioactivity in surface waters, but no significant increase had been noted to October 1, 1961.

For the first two years of the network operations, beta determinations were made on weekly samples. Alpha determinations were reported generally on composites of more than one weekly sample.

Beginning January 1, 1960, the frequency of beta determinations varied depending on the

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status of each particular station. For the first operating year of each new station, analyses were being conducted weekly. Weekly analyses were to be continued indefinitely from all stations which may be affected by waste discharges from nuclear installations. Semimonthly determination (on composites of 2 or 3 weekly samples) were conducted for stations which still showed some beta activity above background. Monthly determinations (on composites of all samples received from a station during the month) were conducted on samples from streams where beta activity was at background levels.

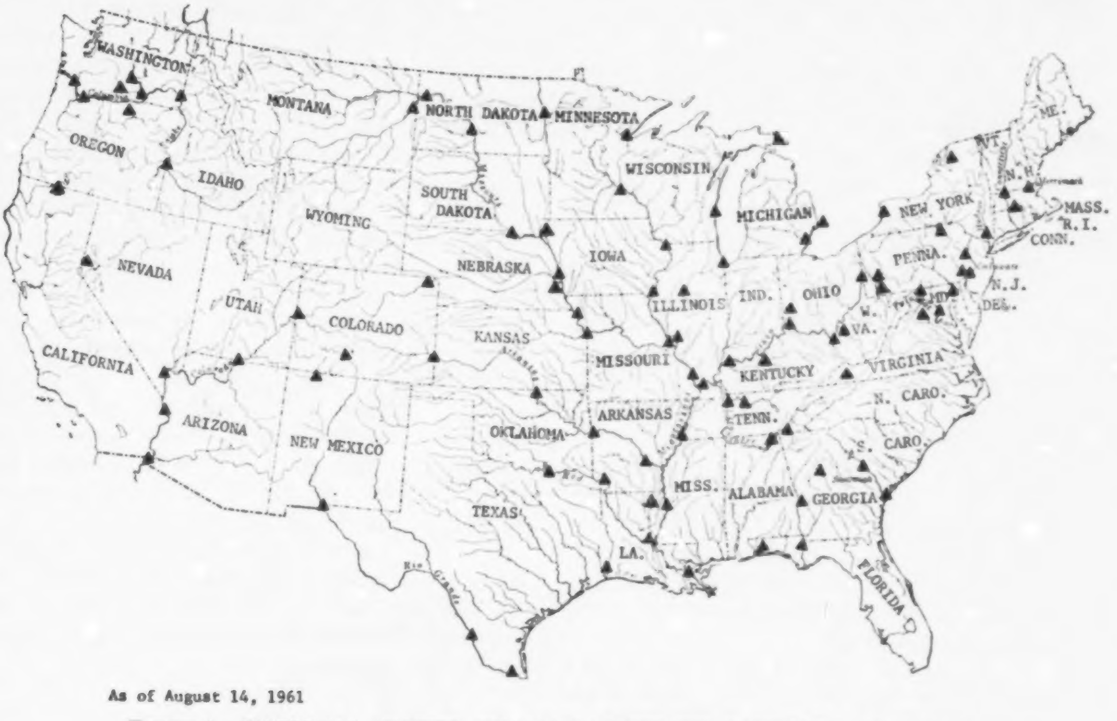
Beginning January 1, 1960, the frequency of alpha determinations also was changed. For the first operating year of each new station, analyses were to be done weekly. Weekly determinations, or semimonthly determinations on composites of 2 or 3 weekly samples, were conducted at some collecting points on the Animas and Colorado Rivers. The remainder of the stations had determinations made monthly on composites of all samples taken during that quarter. Schedules of determinations were so arranged that each station had one gross alpha determination each month.

The following changes were instituted on September 1, 1961, following resumption of nuclear weapons testing:

1. Gross beta counts will be made on all samples collected. (Compositing weekly samples for monthly or semimonthly gross alpha and beta counting will cease).
2. Beginning with samples collected October 1, 1961, strontium-90 determinations will be made on a three months composite of weekly samples.

Gross alpha counts will be made on one sample for each stations each month, unless there is evidence of alpha activity. In the later instance, an alpha determination will be made on a weekly or bi-weekly basis depending on what is considered the norm for a particular station.

All data reported in table 1 represent the average of all information available for the month indicated. Reported strontium-90 data are the results of determinations on three-


WASHINGTON
OREGON
MONTANA
NORTH DAKOTA
MINNESOTA
IDAHO
WYOMING
SOUTH DAKOTA
WISCONSIN
MICHIGAN
NEW YORK
VT.
ME.
N.H.
MASS.
R.I.
CONN.
NEVADA
UTAH
COLORADO
NEBRASKA
IOWA
ILLINOIS
IND.
OHIO
PENNA.
N.J.
DEL.
MD.
W. VA.
CALIFORNIA
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
LA.
FLORIDA
Rio Grande

As of August 14, 1961

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS

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TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Concentrations in μμc/liter]

Station	Quarter ending March 31, 1961	May 1961					
		Beta activity			Alpha activity		
	Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh Pa.	[a] —	<1	2	2	0	0	0
Animas River: Cedar Hill, N. Mex.	—	14	0	14	8	2	10
Apalachicola River: Chattahoochie, Fla.	—	0	0	0	1	0	1
Arkansas River:							
Coolidge, Kansas	—	0	0	0	3	25	28
Ponca City, Okla.	—	0	0	0	15	1	16
Big Sioux River: Sioux Falls, S. Dak.	—	0	0	0	1	0	1
Chattahoochie River:							
Atlanta, Ga.	—	0	0	0	0	0	0
Columbus, Ga.	0.3	0	0	0	0	0	0
Colorado River:							
Loma, Colo.	0.4	5	0	5	3	2	5
Page, Ariz.	—	51	4	55	44	12	56
Boulder City, Nev.	—	0	3	3	0	4	4
Parker Dam, Ariz.-Calif.	—	0	2	2	<1	7	7
Yuma, Ariz.	1.2	0	0	0	0	2	2
Columbia River:							
Wenatchee, Wash.	0.7	0	5	5	0	1	1
Pasco, Wash.	1.0	90	377	467	—	—	—
Bonneville Dam, Oreg.	—	52	152	204	—	—	—
Clatskanie, Oreg.	—	27	67	94	0	0	0
McNary Dam, Oreg.	—	59	158	217	0	<1	<1
Delaware River:							
Martins Creek, Pa.	—	0	0	0	0	0	0
Philadelphia, Pa.	0.6	0	0	0	0	1	1
Great Lakes:							
Buffalo, N. Y.	0.6	—	—	—	—	—	—
Port Huron, Mich.	—	14	16	30	0	0	0
Duluth, Minn.	0.4	0	0	0	0	0	0
Milwaukee, Wis.	—	0	<1	<1	0	<1	<1
Sault Ste. Marie, Mich.	—	0	0	0	0	0	0
Hudson River: Poughkeepsie, N. Y.	0.4	0	0	0	0	0	0
Illinois River: Peoria, Ill.	—	3	0	3	2	3	5
Kanawha River: Winfield Dam W. Va.	0.2	—	—	—	—	—	—
Klamath River: Copco, Oreg.	—	0	<1	<1	0	0	0
Little Miami River: Cincinnati, Ohio	1.1	0	0	0	0	1	1
Mississippi River:							
Minneapolis, Minn.	—	0	0	0	1	2	3
E. St. Louis, Ill.	—	11	0	11	8	0	8
Cape Girardeau, Mo.	0.7	—	—	—	—	—	—
West Memphis, Ark.	—	0	0	0	—	—	—
Missouri River:							
Williston, N. Dak.	0.8	15	51	66	5	6	11
Yankton, S. Dak.	—	0	0	0	1	4	5
Omaha, Nebr.	—	0	0	0	1	5	6
St. Joseph, Mo.	—	19	0	19	3	5	8
Kansas City, Kans.	1.4	—	—	—	—	—	—
St. Louis, Mo.	1.1	16	2	18	15	2	17
Ohio River:							
East Liverpool, Ohio	—	0	8	8	0	0	0
Huntington, W. Va.	—	0	0	0	2	1	3
Cincinnati, Ohio	0.3	0	0	0	0	0	0
Cairo, Ill.	—	5	2	7	1	1	2
Potomac River:							
Hagerstown, Md.	—	0	0	0	0	0	0
Great Falls, Md.	1.3	—	—	—	—	—	—
Red River, South:							
Index, Ark.	0.4	5	0	5	0	0	0
Denison, Tex.	—	0	0	0	0	16	16
Rio Grande River:							
Alamosa, Colo.	—	0	0	0	0	2	2
El Paso, Tex.	0.4	0	<1	<1	0	3	3
Laredo, Tex.	0.4	0	0	0	1	3	4
Sabine River: Ruliff, Tex.	—	1	2	3	1	<1	1
St. Lawrence River: Massena, N. Y.	—	0	0	0	0	1	1
Savannah River: Port Wentworth, Ga.	0.4	0	13	13	0	0	0
Snake River: Wawawai, Wash.	—	0	14	14	0	1	1
Susquehanna River: Conowingo, Md.	—	0	1	1	0	0	0
Tennessee River:							
Chattanooga, Tenn.	0.8	2	91	93	0	0	0
Bridgeport, Ala.	1.5	26	68	94	0	0	0
Yakima River: Richland, Wash.	—	0	0	0	<1	0	<1
Yellowstone River: Sidney, Mont.							

[a] Dash denotes no sample received or no determinations made.

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month composite samples for a period ending in the month shown. The data were determined on analytical schedules in effect till September 1, 1961.

Additional information and data may be obtained from the following sources:

(1) *National Water Quality Network Annual Compilation of Data*, PHS Publication. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price $1.50.

(2) "Report on National Water Quality Control Network," submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167-169.

(3) Setter, L. R., Regnier, J. E., and Diephaus, A., "Radioactivity of Surface Waters in the United States," J. AWWA *51*, 1377 (1959).

(4) Straub, C. P., Setter, L. R., Goldin, S., and Hallbach, P. F., "Strontium-90 in Surface Waters," J. AWWA *52*, 756 (1960).

(5) Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data*, Vol. I, No. 7 (1960).

Monitoring of Water Supplies Around the Nevada Test Site

By contract with the Atomic Energy Commission, the Public Health Service has conducted an offsite monitoring program around the Nevada Test Site (NTS) since 1955. Included in the program have been measurements of radioactivity in water supplies. These data have been reported in the Atomic Energy Commission's 13th, 14th, 18th, and 23rd Semiannual Reports to Congress and by the Public Health Service in the 1957 congressional hearings, "The Nature of Radioactive Fallout and Its Effects on Man."

TABLE 1.—DESCRIPTION OF WATER SAMPLING POINTS, NEVADA TEST SITE

Location	Source	Population served
Las Vegas	13 wells—650 to 1,250' depth plus Lake Mead supply.	40,000.
Game Reserve	400' drilled well	20.
Indian Springs	600' drilled well	Average 250.
Pahrump	75' driven well	10-50.
Ash Meadows	Spring 25' deep	8.
Lathrop Wells	3 wells—600' deep	Average 15.
Beatty	Spring	550.
Lida Junction	125' drilled well	2-10.
Goldfield	Spring	Average 200.
Tonapah	2 drilled wells—[illegible] depth	Average 1,500.
Warm Springs	Multiple springs—no improvement.	10.
Diablo	Well	State highway station.
Lincoln Mine	2 driven wells	3.
Caliente	Springs	Average 10-12.
Crystal Springs	Free flowing spring	0.
Alamo	2 wells—50-67' deep	Average 175.
Pahranagat Lake	Surface	Not used for domestic purposes.
Butler Ranch	Flowing spring	1.
Warm Spring Ranch.	Flowing spring from earth fault.	Public park with swimming pool.
Logandale	Drilled well	300.
Ballistic Range	Drilled well	10-15.

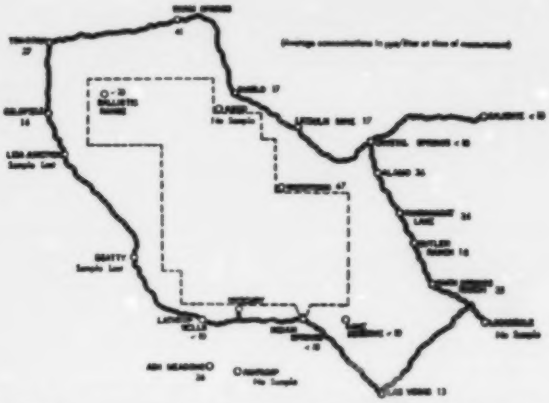

FIGURE 1.—GROSS BETA MEASUREMENTS IN WATER SUPPLIES IN OFF-SITE AREAS OF THE NEVADA TEST SITE FOR MARCH - APRIL 1961

Figures 1 and 2 summarize gross beta measurements in water supplies located in the NTS offsite area for March-June 1961.

The lower limit of detectability with the equipment used is about 10 micromicrocuries per liter.

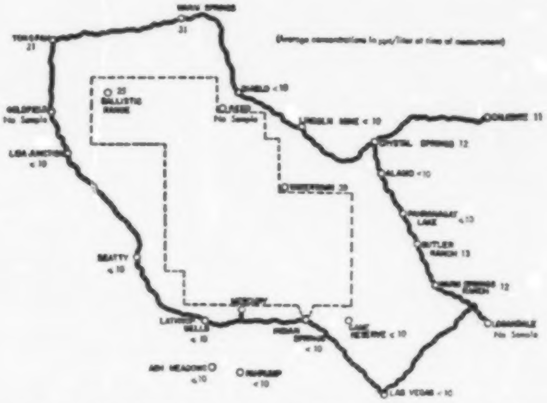
TONOPAH 21
WARM SPRINGS 31
BALLISTIC RANGE 25
GOLDFIELD No Sample
LIDA JUNCTION < 10
DIABLO < 10
LINCOLN MINE < 10
CALIENTE 11
CRYSTAL SPRINGS 12
ALAMO < 10
PAHRANAGAT LAKE < 13
BUTLER RANCH 13
WARM SPRINGS RANCH 12
LOGANDALE No Sample
BEATTY < 10
MERCURY
LATHROP WELLS < 10
INDIAN SPRINGS < 10
GAME RESERVE < 10
ASH MEADOWS < 10
PAHRUMP < 10
LAS VEGAS < 10

FIGURE 2.—GROSS BETA MEASUREMENTS IN WATER SUPPLIES IN OFF-SITE AREAS OF THE NEVADA TEST SITE FOR MAY - JUNE 1961

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SECTION IV. — OTHER DATA

External Gamma Activity

Radiation Surveillance Network, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown in the following table are within the variance anticipated due to differences in normal background and in instrument response characteristics. These values are the results of measurements taken before the resumption of nuclear weapons testing.

TABLE 1.—EXTERNAL GAMMA ACTIVITY—JUNE, JULY, AND AUGUST 1961

[Average dose-rate in mr/hr]

Station location	June	July	August	Station location	June	July	August
Anchorage, Alaska	0.01	0.01	0.01	Minneapolis, Minn	0.01	(a)	0.01
Fairbanks, Alaska	(a)	(a)	(a)	Pascagoula, Miss	(a)	(a)	(a)
Juneau, Alaska	0.01	0.01	0.01	Jefferson City, Mo	0.01	0.01	0.01
Pheonix, Ariz	0.02	0.02	0.01	Helena, Mont	0.03	0.03	0.03
Little Rock, Ark	0.02	0.02	0.02	Trenton, N.J	0.02	0.02	0.02
Berkeley, Calif	0.01	0.01	0.01	Sante Fe, N. Mex	(a)	(a)	(a)
Los Angeles, Calif	(a)	(a)	(a)	Albany, N.Y	(b)	0.02	0.03
Denver, Colo	0.02	(a)	(a)	Gastonia, N.C	0.02	0.02	0.02
Hartford, Conn	0.01	0.01	0.01	Oklahoma City, Okla	0.01	0.01	0.01
District of Columbia	0.02	0.02	0.02	Ponca City, Okla	0.03	0.03	0.03
Jacksonville, Fla	0.01	(a)	(a)	Portland, Oreg	0.02	0.02	0.02
Atlanta, Ga	(a)	0.02	0.02	Harrisburg, Pa	0.01	0.01	0.01
Honolulu, Hawaii	0.03	0.02	0.03	Providence, R.I	0.02	0.02	0.02
Boise, Idaho	0.01	0.01	0.01	Columbia, S.C	0.02	0.02	0.02
Springfield, Ill	0.01	0.01	0.02	Pierre, S.D	0.02	0.02	0.02
Indianapolis, Ind	0.01	0.01	0.01	Austin, Tex	0.01	0.01	0.01
Iowa City, Iowa	0.01	0.02	0.02	El Paso, Tex	0.02	0.02	0.02
Topeka, Kans	0.03	0.02	0.02	Salt Lake City, Utah	0.02	0.02	0.02
New Orleans, La	0.02	(a)	0.01	Richmond, Va	0.01	0.01	0.01
Baltimore, Md	0.02	0.02	0.02	Seattle, Wash	0.02	(a)	0.02
Lawrence, Mass	0.02	0.02	0.02	Madison, Wis	0.01	0.02	0.02
Lansing, Mich	0.02	(a)	(a)	Cheyenne, Wyo	0.02	0.02	0.02

[a] No data received.
[b] Meter not in operation.

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RADIOLOGICAL HEALTH CONSIDERATIONS AND FINDINGS RELATED TO THE USE OF MEDICAL AND DENTAL X-RADIATION

The following articles are the fourth and fifth in a series of presentations intended to discuss or present information, philosophical considerations, or summaries of data concerning the radiological health aspects of medical and dental X-radiation. These discussions will be related primarily to the factors involved in the ultimate reduction of the somatic and genetic dose delivered to the general population.

Previous discussions which were concerned with reflections on plans to control radiation exposure in the United States, realistic appraisals of leakage radiation from diagnostic type protective tube housings, and findings obtained from a radiological safety survey of dental X-ray units in Texas appeared in *Radiological Health Data*, Volume II, Numbers 8 and 10.

The first of the following two articles discusses and presents findings related to the use and distribution of medical and dental X-radiation obtained from the New York City radiation control program. The material for this article was supplied by Hanson Blatz, Director, Office of Radiation Control, New York City Department of Health.

The second article, an abstract of the "Second Report of the Committee on Radiological Hazards to Patients," presents a survey of medical and dental uses of radiation in Great Britain and derives a genetic dose to the population based on data obtained for the last quarter of 1957.

Preliminary Radiological Health Findings Concerned With The Use and Distribution of Medical and Dental X-Radiation in New York City[1]

New York City has required the registration of clinical X-ray equipment for over thirty years, but the radiological health program was not extensive. Large scale activities were initiated subsequent to the enactment of a new radiation code in 1958. As a direct result of organization, training of personnel and trial inspections, a full scale program went into effect during the early months of 1959.

A considerable effort was expended to obtain nearly complete registration of all sources which now total almost 13,000 installations. In addition to several thousand radioactive sources, these installations house approximately 17,000 X-ray units.

The budget for the first year (1959-60), about $170,000 allowed for a staff of ten and the purchase of a considerable amount of new equipment. The staff has been increased to thirty with an authorization for thirty-eight and a budget of about $240,000 for 1961-62. About one-third of the cost is borne by registration fees.

Major emphasis has been placed on assisting physicians and dentists to reduce to a minimum the radiation dose to patients from X-ray equipment. This source of radiation constitutes an estimated 96 percent of all manmade radiation to which the population is exposed. In our experience, it has been possible to reduce this condition significantly.

Some pertinent statistics obtained from the first two and one-half years of X-ray inspections conducted in New York City are presented below.

Registration of Sources

Recognizing that an accurate knowledge of all sources of radiation is basic to any control program, a systematic approach was initiated for collecting data concerning their nature, location, and manner of use. Registration requires the completion of a carefully planned

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[1] For a more detailed discussion of this radiation control program, see:

Blatz, H., "A Comprehensive Radiation Control Program in New York City," *Radiology*, *74*, 3, pp. 474-479, March 1960.

Baumgartner, L. Blatz, H., "Control of Common Radiation Hazards in New York City," *Public Health Reports*, *76*, 7, pp. 583-590, July 1961.

TABLE 1.—REGISTRATION STATISTICS

Users of X-radiation	Radiation installations registered[1]	X-ray units in New York City[2] (all types)	Medical diagnostic X-ray installations	Medical X-ray deep-therapy installations
Chiropractors	[3] 6	[4] 500		
Dentists	6,409	6,596		
Hospitals	343	1,238		78
Industrial medicine	209	[4] 280		
Osteopaths	65	[4] 100		
Physicians	5,128	7,831		136
General practitioners			2,401	
Internists			1,097	
Pediatricians			206	
Radiologists			205	
Other physicians			932	
Podiatrists	442	[4] 450		
Veterinarians	70	[4] 125		
Total	12,672	[4] 17,120	4,841	214

[1] Diagnostic and therapeutic X-ray units and radiographic materials.

[2] The number of X-ray units and the number of installations are not in agreement because many installations have more than one unit.

[3] Pending conclusion of the lawsuit by the Chiropractors Association against the State Health Commissioner to test the constitutionality of a regulation banning the use of x-rays by chiropractors, no effort was made to register X-ray equipment in the 1,075 chiropractors' offices in New York City. The six listed registered voluntarily.

[4] Estimated.

questionnaire, as well as a $15.00 remittance. This fee covers registration for two years. Thereafter, payment of $10.00 is required biennially. In order to keep registration up to date, the radiation code has been amended to require dealers and manufacturers to notify the Department of Health within 10 days after delivery or installation of radiation equipment. Experience indicates that such notifications are being received regularly. Table 1 summarizes the pertinent registration statistics as of March 15, 1961. As of this date, 4,583 fluoroscopic, and 3,248 medical radiographic units in physicians' offices have been registered with the New York City Department of Health. With 6,596 dental units and all others (hospitals and other offices) the total is about 17,000.

Chiropractors, currently involved in litigation regarding authority to use X-rays, are the only group not registered essentially 100 percent. The Office of Radiation Control estimates that there may be as many as 400 chiropractors using X-ray equipment.

Even though the registration requirement was widely publicized through the press, radio, and professional and business groups, it took almost a year and a half to attain complete registration. Many hundreds of personal visits and telephone calls were made to those who had not responded to several notices informing them of the need to register. Apparently, the difficulty was in communication, for there was little resistance once contact was made. The medical societies requested each member who had not registered to do so; in fact, they, as well as the dental societies, have generally approved the radiation control program.

Inspection Program—Major Deficiencies

In preparation for the inspection program, the most serious deficiencies in X-ray equipment design, installation, and use were listed, and standards were formulated against which equipment or techniques could be evaluated. A standard operating procedure and a checklist were developed for inspecting each type of X-ray installation, including medical diagnostic X-ray, medical therapeutic X-ray, mobile or portable X-ray, fluoroscopic X-ray, and dental X-ray installations. All the inspection criteria were reviewed and approved by the Mayor's Technical Advisory Committee.

An initial group of public health sanitarians, all with inspection experience, were taken to the showroom of one of the local X-ray dealers and to one of the largest city hospitals for intensive training in inspecting X-ray equipment. These sessions were supplemented by classroom lectures and demonstrations covering the principles of radiation protection.

So that the most serious hazards can be corrected as soon as possible, each installation is given a preliminary inspection limited to basic faults, and secondary matters are relegated to followup inspections.

The first inspection consists of a visual examination against a standard checklist. No radiation detection instruments are used. A fluorescent screen is used to determine the area covered by an X-ray beam, a very important criterion of the integral dose. The screen is also used to determine any gross deficiency in shielding; for example, replacement of protective lead glass by a piece of ordinary plate glass. A special gauge for measuring aluminum filter thickness and a tape measure for several other measurements are the only equipment necessary. The checklist covers such items as the size of the X-ray beam used, for example, in chest radiography and in radiography of extremities, filter thickness, the distance from fluoroscope tube to the panel, limits of fluoroscopic shutters, and relation of the X-ray control and radiographic exposure switch to operator's shield.

The X-ray equipment operator (technician or physician) is asked to demonstrate a few common techniques, mainly to determine what size X-ray beam is used. The inspector acts as the patient, except that no exposure is made. The following beam diameters are used as guides in determing when the beam is larger than clinically necessary:

TABLE 2.—COLLIMATION CONSIDERATIONS

Film size (inches)	Film diagonal (inches)	Beam diameter (inches)
8 by 10	12¾	15
10 by 12	15⅝	17½
11 by 14	17¾	20
14 by 17	22	24

Experience has shown that when these or smaller diameters are used, corner cutoff will frequently appear on exposed films. Absence of such cutoff in all films generally indicates inadequate collimation.

In addition to marking the checklist, the inspector sketches, on the back of the form, a scale drawing of the X-ray room and the location of the equipment and the controls. He also indicates the nature of the occupancy of all adjacent areas. For installations where structural shielding appears to be critical, but where there is no positive evidence that it is actually installed, the inspector notes this fact for a followup survey. Inability to measure readily both the fluoroscopic filter and distance from tube to panel, and any indication that lead glass or a protective tube housing is inadequate, also call for special notation.

If necessary, a second inspection is made of fluoroscopic equipment to measure the dose rate. This measurement is required only when the filter thickness and the tube-to-panel distance cannot be measured, or when the voltage and current settings cannot be reasonably estimated. Actual measurements of a sample of the equipment on our list indicates that it is only when these factors cannot be determined that the fluoroscopic dose rate can differ by more than about 25 percent from the value given on standard X-ray output tables.

In choosing which equipment to inspect first, certain priorities were obvious. Machines used most frequently (those in large hospitals, for example), machines used with heavy dosage, and machines built before modern safeguards and structural shielding were given first priority. Equipment used in the examination of children and pregnant women were given second priority.

This streamlining of the program, plus, of course, the geographic compactness of the area, has enabled each inspector to complete about five inspections a day. In the first one and a half years, more than 4,000 visits had been made by a staff of four or five inspectors. Spot reinspections indicate that these preliminary inspections have led to the elimination of many of the most serious deficiencies. Table 3 presents a summary of major deficiencies found in medical and dental X-ray installations

TABLE 3.—INSPECTION STATISTICS

Type and number of X-ray units and defects	Percent of units inspected in each type
Medical fluoroscopic unit (1,687):	
Shutters did not adequately limit X-ray beam	59.5
Inadequate filtration	19.4
Protective aprons not available	8.5
Protective gloves not available	6.5
Dark adaptation goggles not available	15.8
Room darkening facilities inadequate	6.1
Required timer not installed	32.0
Medical radiographic unit (1,648):	
Excessive beam size (chest X-rays)	66.0
Inadequate filtration	25.0
Inadequate protection for operator	63.0
Mobile medical radiographic unit (288):	
Inadequate filtration	31.0
Inadequate protection for operator	2.8
Protective apron unavailable	16.0
Medical therapy unit (127):	
Inadequate tube shield (obsolete type)	4.0
Inadequate identification of filters	19.7
Inadequate timer	14.2
Inadequate protection for operator	7.8
Dental radiographic unit (2,716):	
Excessive beam size	27.5
Inadequate filtration	33.7
Inadequate protection for operator	5.0

in New York City. These data are the results of 6,466 X-ray units inspected through March 1961. (As of August 1, 1961, 8,890 units have been inspected.)

At first it was found that some surgical supply houses (as distinguished from the major X-ray manufacturers, who usually sell directly in the New York City area) were installing medical and dental X-ray equipment that did not meet the basic safety standards or they were not being properly installed. The New York City Health Code fixes responsibility for these matters with the seller. Prompt followup has served to inform suppliers of the standards they must meet and it has resulted in much improvement in recently installed equipment. For example, an X-ray table and control installed side by side without a shield for the operator is rarely seen anymore. This arrangement was common in the past. The suppliers' responsibility is believed to be a unique feature of the program.

Structural Shielding

A third inspection is made if the initial inspection report indicates a need for a test of structural shielding, particularly when the shielding is intended to protect adjacent rooms not under control of the owner or operator of the equipment. This test is made by a team specially trained for the job. The recommendations of the National Committee on Radiation Protection and Measurements (NCRP) and those of the Federal Radiation Council are quite specific and conservative in limiting the dose to occupants of areas not controlled by the owner or operator of an installation. The very low limit of 0.5 rem per year has recently been established.

REFERENCES

(*1*) New York City Board of Health, New York City Health Code, Article 175, "Radiological Hazards," New York, 401-412, 1959.

(*2*) Federal Radiation Council, "Background Material for the Development of Radiation Protection Standards," Staff Report No. 1, Government Printing Office, Washington, D.C., 1960.

(*3*) National Bureau of Standards, "X-ray Protection," Handbook 60, Government Printing Office, Washington, D.C., 1955.

(*4*) National Bureau of Standards, "Medical X-ray Protection up to Three Million Volts," Handbook 76 (Supersedes Handbook 60), Government Printing Office, Washington, D.C., 1961.

(*5*) National Bureau of Standards, "Protection Against Radiation from Sealed Gamma Sources," Handbook 73, Government Printing Office, Washington, D.C., 1960.

Determination Of The Genetic Dose To The Population Of Great Britain[1]

Committee on Radiological Hazards to Patients
Ministry of Health for England, and,
Department of Health for Scotland

In recent years the hazards of radiology have attracted special attention. More precise knowledge of them was needed to guide the physician who has to balance the benefits against the risks for any individual patient. Consequently, the Committee on Radiological Hazards to Patients was formed in 1956 to examine the question and to make recommendations. "The Committee therefore set itself the task of measuring in detail the present extent of medical and dental radiology over the whole of Great Britain, of assessing the levels of radiation dosage thus produced, and finally of recommending ways and means of reducing this dosage without detriment to the needs of the patient or the health of the population."

In this report, the study has been limited to the genetic dose. Estimation of the somatic dose (possible hazard to the individual during his life-time) is a more complicated procedure to which further study is being given.

"If the mutational effect of radiation is proportional to the dose received by the germ

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[1] Permission for publishing this abstract has been obtained from the Controller of Her Britannic Majesty's Stationery Office. The original report, "Radiological Hazards to Patients, Second Report of the Committee," is available from the British Information Services, 45 Rockefeller Plaza, New York 20, New York, price $1.08.

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cells and is irreversible, the importance of a given dose will depend on age. The potential effect of the dose on future generations will be greatest in a young person having a high expectancy of future parenthood, less in an older person and nil at an age when child expectancy has ceased. A genetic dose to the individual is therefore defined as the dose to the gonads, adjusted to allow for the child expectancy of that individual. The genetic dose to the population is then defined as the gonad dose which, if given to every member of that population, would have the same effect as the sum of the individual doses actually received."

General Diagnostic Radiology

During a week in May 1957, a survey by questionnaire was made of the numbers and types of all X-ray examinations conducted, of the number of films used, and the apparatus available in all National Health Service hospitals and chest clinics, in dental surgeries and in a few other institutions in Great Britain.

A separate physical dose survey during December 1957 was made on a random selection of a quarter of the National Health Service hospitals and chest clinics. This collection of physical data was undertaken on a large scale by hospital physicists in all the hospital regions, some 5,414 examinations involving 13,800 measurements being made in 130 hospitals selected to give a representative cross-section of radiological practice in hospitals and chest clinics.

During the week of the first survey, the total number of radiological examinations (including fluoroscopy) carried out in all National Health Service hospitals and chest clinics was 259,447. Using this value, the total number of examinations made in 1957 can be estimated as 13.0 million.

The averages of the measured doses to the male, female and fetal gonads are given in table 1 for the eight groups of examinations which together contribute more than 90 percent of the total genetic dose.

Genetic doses calculated from the survey data are also given in table 1. Contributions to the total genetic dose are given for each of the eight examination groups of table 1 and for all other examinations grouped together. These contributions are given separately for the male, female and fetus and totaled in the last column. It is evident that 5 examinations (obstetric abdomen, pyelography, pelvimetry, pelvis, and hip) together provide over 80 percent of the total genetic dose.

"The annual genetic dose from general diagnostic radiology in National Health Service Hospitals amounts to 13.2 milliroentgens (mr) to which a small increment, estimated at 0.9 mr, has been added to take into account general diagnostic radiology performed outside the National Health Service. The total annual genetic dose of 14.1 mr per person from general diagnostic radiology is therefore less than the earlier estimate of 22 mr per head per year shown by the Medical Research Council's report of 1956."

Two important conclusions can be drawn from the physical dose survey. First, the gonadal dose in diagnostic radiology is not necessarily reduced by making the beam of

TABLE 1.—GENERAL DIAGNOSTIC RADIOLOGY, 1957

[Doses in milliroentgens]

Type of examination	Mean gonadal dose per examination			Annual genetic dose per person to the entire population of Great Britain			
				Fractional contribution from			
	Male	Female	Fetus	Male	Female	Fetus	Total
Chest, heart, lung	3	5	6	0.14	0.29	0.05	0.48
Barium meal	44	333	448	0.11	0.36	0.04	0.51
Abdomen	105	183	281	0.22	0.32	0.06	0.60
Abdomen, obstetric		367	723		1.12	2.27	3.39
Intravenous pyelography	765	585	843	0.96	0.69	0.09	1.74
Pelvimetry		745	885		0.55	0.60	1.15
Pelvis, lumbar spine lumbo-sacral joint	370	392	536	1.72	1.17	0.22	3.11
Hip, upper femur	740	102	154	1.33	0.14	0.01	1.48
All other examinations				0.35	0.39	0.04	0.78
Total				4.83	5.03	3.38	13.24

X-rays more penetrating, an optimum is reached at about 70 kvp with 1 mm of aluminum filtration. Second, a few hospitals with faulty techniques can contribute a proportionately large fraction of the total genetic dose. "If all techniques were raised to the standard shown by the 25 percent of hospitals showing the lowest doses, the annual genetic dose would be lowered to somewhere in the region of 2 mr per person."

Mass Miniature Radiography of the Chest

An assessment of the gonadal dose from mass miniature radiography of the chest was made by means of a survey in which more than 600 measurements were carried out on four different types of mass radiography equipment representative of those used throughout the country.

Statistics for 1958 show that 4,278,108 mass miniature radiography examinations were made in Great Britain and led to the discovery of 17,569 cases of pulmonary tuberculosis requiring supervision, 3,503 cases of lung cancer, 10,161 cardiac abnormalities, and 3,741 cases of pneumoconiosis. "It is clear that any possible hazard has to be balanced against these findings."

"The mean gonad dose per examination given by the present measurements is 0.090 mr for males and 0.092 for females. The average fetal gonad dose is assumed to be the same as that for the ovary. The genetic dose per person is then 0.01 mr per year. The contribution from mass miniature radiography to the genetic dose from diagnostic radiology as a whole is, therefore, extremely small."

Dental Radiography

"The first statistical inquiry into the frequency of diagnostic radiology included all hospitals and dental surgeons in the country. The replies received from the hospitals indicated that only a small fraction of them (13 percent) undertook dental radiology." Of the 16,000 questionnaires sent to dental surgeons, only 43 percent were returned. "There is no means of telling whether the figures given by this proportion is representative of the total. It might well be that dental surgeons not using X-rays at all tended not to reply and that the sample is thereby appreciably biased. Data on technique, however, might be less liable to bias and from the returns received an average of two films per dental examination was calculated." This figure can be combined with information on the annual dental film consumption to give an estimate that approximately 2 million dental X-ray examinations were made during 1957 in Great Britain.

It was found impracticable to include dental work in the general survey of diagnostic radiology carried out by the physicists so a method of using a piece of very sensitive photographic film enclosed between fluorescent intensifying screens in a specially designed cassette was devised. The cassette was fixed to one side of a plastic foam prism which could be firmly strapped across the seat of a dental chair so that the film was at an angle of 45° to the seat and facing the body of a patient sitting in the chair. On the average, 70 exposures were recorded in the measurements made in each of 12 National Health Service hospitals, 12 dental departments serving the armed forces, and 130 private dental surgeries.

"The mean gonad dose per examination derived from these measurements is 0.27 mr for each sex and the annual genetic dose per person calculated on the basis of 2 million examinations per year is 0.01 mr."

External Radiotherapy of Non-malignant Disease

All hospitals in England, Wales and Scotland were requested to complete questionnaires showing the number of patients treated for non-malignant conditions by X-rays during the three-month period April 29 to July 29, 1957. Data from 13,950 cases in hospitals and 1,015 cases in private practice were reported. The total of 60,000 patients treated per year may be a little below the grand total as it was estimated that this represented 90 percent of the total number of treatments carried out in hospitals and about one-third of those in private practice.

To determine the gonadal dose for the various types of treatment, a representative sample consisting of detailed information for 2,262 treatments of non-malignant disease was collected and classified into categories as shown in table 2. "Measurements were made on a model to obtain the male and female gonad doses for various sizes and qualities of X-ray beam directed to 16 regions of the body from the head to the foot . . . The annual genetic dose per person is given for the male, female and foetus in table 2 from which it is evident that the male dose is nearly twice the female dose and that the foetal dose is very small . . . In total, the annual genetic dose from non-malignant radiotherapy is 4.5 mr per person, of which the treatment of skin conditions contributes about one-half and radiotherapy of ankylosing spondylitis about one quarter."

External Radiotherapy of Malignant Disease

The questionnaire sent to all radiotherapy departments in April, 1957, provided information from 14,620 patients undergoing external radiotherapy for malignant disease.

Treatments were assumed to be carried out by standard methods with X-rays generated at 220 kv. In cancer of the breast, bladder, and mouth an additional allowance was made for those cases in which radium was used. The gonadal doses were measured on the model for a treatment regarded as typical for each disease. The normal fertility factors were modified to allow for the reduced expectation of life of persons suffering from different forms of malignant disease and a rough allowance has been made for the loss of fertility caused by the treatment.

The genetic doses from those types of treatment which make significant contributions are listed in table 2. The annual genetic dose per person from the radiotherapy of malignant disease amounts to 0.5 mr. "It is small relative to other radiation doses we have considered, and the unavoidable uncertainties in its estimation do not lead, therefore, to serious error in the total genetic dose from medical radiology . . . In particular, calculations show that the substitution of higher energy radiation in the range 1 to 10 Mev would not materially alter the result."

TABLE 2.—EXTERNAL RADIOTHERAPY OF NON-MALIGNANT AND MALIGNANT DISEASE, 1957

Diagnosis or site of disease	Annual genetic dose in milliroentgens per person				
	Male	Female	Fetus	Total	Percentage
Non-malignant					
Skin condition:					
Benign growths, etc.	0.02	0.07	<0.005	0.09	2
Allergic, etc.	0.34	0.59	0.03	0.96	21
Ringworm	<0.005	0.01	<0.005	0.01	<0.5
Others	1.19	0.27	----------	1.46	33
Glandular enlargements	<0.005	<0.005	<0.005	<0.005	<0.5
Ankylosing spondylitis	1.07	0.08	<0.005	1.15	26
Arthritis, rheumatism	0.04	0.18	0.05	0.27	6
Artificial menopause	----------	----------	----------	----------	----------
Deafness	<0.005	<0.005	<0.005	<0.005	<0.5
Any other non-malignant condition	0.04	0.49	<0.005	0.53	12
Total	2.70	1.69	0.08	4.47	100
Malignant					
Male genitalia	0.22	----------	----------	0.22	42
Bladder	0.04	<0.005	----------	0.04	8
Bone	0.03	0.04	----------	0.07	13
Connective tissue	0.02	<0.005	----------	0.02	4
Lymphatic and hemopoietic tissue	0.03	0.02	----------	0.05	10
Skin	0.05	0.04	----------	0.09	17
Others	0.02	0.01	----------	0.03	6
Total	0.41	0.11	----------	0.52	100

Internal Administration of Radioactive Isotopes

In recent years radioactive isotopes have been increasingly used in diagnosis and in the treatment of non-malignant and malignant disease. "From the information available on the radioactive isotopes in clinical use, the gonad dose from each had been estimated for an amount of one millicurie administered." These doses have been combined with the results of the three month survey which gave the numbers of patients treated and the amounts administered, and with the approximate fertility factors giving an estimate of the genetic dose.

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"As in the case of the external radiotherapy of malignant disease, modification of the normal fertility factors have been made in the calculations for some of the types of treatment." Table 3 shows those radioisotopes and types of examination and treatment of 7,442 patients which lead to a significant genetic dose. "In calculating these figures it may be noted that a range of values of the gonad dose per millicurie administered has been reported . . . The higher figures have been taken so that our estimate is likely to a be a maximum . . . In total, the annual genetic dose per person from all the present uses of radioisotopes in medicine amounts to 0.18 mr per person of which 85 percent arises from therapy."

"The only internally administered radioactive isotopes which give rise to any appreciable gonad dose are iodine-131 and phosphorus-32 and this occurs during treatment of thyrotoxicosis, polycythaemia, and thyroid cancer in roughly equal proportions."

TABLE 3.—INTERNAL ADMINISTRATION OF RADIOACTIVE ISOTOPES, 1957

[Annual genetic dose in milliroentgens per person]

Use	Isotope	Dose	Percentage
Diagnosis: test doses			
Thyroid function	Iodine-131	0.011	6
Carcinoma of thyroid	Iodine-131	0.005	3
Other investigations	Phosphorus-32	0.012	6
Therapy:			
Non-malignant conditions:			
Thyrotoxicosis and other non-malignant conditions of thyroid	Iodine-131	0.049	27
Polycythaemia	Phosphorus-32	0.059	33
Malignant diseases:			
Carcinoma of thyroid	Iodine-131	0.045	25
Total		0.181	100

Recommendations

The present practice of radiology in different specialties together with the results of the surveys was studied by nine clinical panels. The following are the major recommendations, quoted directly, on methods to reduce the dose to the gonads in diagnostic and therapeutic radiological practice without detriment to the value of these procedures:

I. GENERAL

A. There should be clear-cut clinical indications before any X-ray examination is undertaken, and it should be ascertained whether there has been any previous radiological examination which would make further examination unnecessary. For this purpose the case sheet should have a section labelled "previous X-rays."

B. To reduce unnecessary examinations, arrangements should be made for the ready availability of previous films and for the routine transfer of films from one hospital to another.

C. All requests for examinations should state precisely the clinical indications and the information required.

D. There should be consultation between clinician and radiologist before extensive or repeated radiological examinations of young individuals are undertaken. It must be realised that radiological exposure is just as much the responsibility of the clinician as of the radiologist.

E. To reduce the necessity for repeat investigation strict attention should be paid to adequate preparation of the patient before abdominal investigation.

F. Special precautions should be adopted in the radiography of pregnant women. Only essential examinations should be carried out during pregnancy and particular care should be taken to avoid irradiation of the foetus whenever possible. In all women of child-bearing age the clinician requesting the examination should never overlook the possibility of early pregnancy.

G. Any previous history of radiotherapy should be ascertained before a new course of treatment is undertaken. Permanent records of all radiotherapy should be maintained and be readily available for transfer from one hospital to another.

H. Consideration should always be given to alternative methods of treatment before radiotherapy for non-malignant conditions is undertaken.

II. TECHNIQUES

In every radiological examination, care should be taken to reduce to a minimum the irradiation of the gonads. The steps necessary to this end are discussed throughout the Report. In particular, strict attention should be paid to the following:—

A. General to all forms of radiology

1. *Limitation of field size*

Strict limitation of field size to the area necessary for the particular examination or treatment should be routinely practised. In diagnostic radiology, this should be done by fitting light beam diaphragms rather than circular cones, particularly when a large field size is used.

2. *Beam direction*

Whenever possible, the beam should not be directed towards the gonads and this should be borne in mind particularly in examinations or treatments of the limbs, especially of the hands with the patient in the sitting position.

3. *Gonad shields*

Adequate gonad shields should invariably be used in examinations or treaments which are likely to give a high gonad dose, unless they interfere with the proposed examination or treatment.

4. *Immobilizing devices*

In the examination or treatment of children or patients who need support, mechanical devices to ensure immobilization should be used.

B. Particular to radiography

1. *High speed films and screens*

The use of the fastest films and screens consistent with satisfactory diagnostic value is strongly recommended.

2. *Automatic timing devices*

Repeat exposures should be kept to a minimum by the use of photoelectric timers or similar devices. Where these are not practicable, accurately pre-set timing devices should be readily available.

C. Particular to fluoroscopy

1. *Limitation of use*

Fluoroscopy should not be undertaken if the same information can be obtained by radiography. It should not be used for locating metallic foreign bodies at operations as electronic metal-locating equipment is now available.

2. *Dark adaptation*

No fluoroscopic examination should be undertaken without adequate dark adaptation on the part of the clinician undertaking the examination (at least 10 minutes).

3. *Automatic switches*

All fluoroscopy machines should be fitted with a clock, or other timing device, which automactially cuts off the beam after a certain time or a certain dose.

4. *Image intensification*

More general use should be made of image intensification in such examinations as cardiac catheterisation. There is urgent need for more research into the problems of image intensification for medical purposes.

D. Particular to mass miniature radiography

In accordance with the recommendations of our Interim Report, chest examinations of pregnant women should not be carried out with mass miniature techniques, but by full size films with strict limitation of field size. For the chest radiography of children and adults of short stature either technique may be used, so long as adequate steps can be taken to exclude the gonads from the X-ray beam; otherwise large films should be used.

E. Particular to radiotherapy

1. In the treatment of skin conditions, use should always be made of the softest quality of radiation consistent with adequate irradiation of the tissues to be treated.
2. Radiation should not be applied to the ovaries for the production of a temporary artificial menopause, or for the treatment of infertility.

III. EQUIPMENT

A. Checks should be made regularly to ensure that all radiological equipment is

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maintained to the standard laid down in the Code of Pratice for the Protection of Persons Exposed to Ionizing Radiations. Obsolete and erratic equipment should be replaced immediately.

B. The development of automatic devices, and particularly those which reduce the risks of human error, should be actively encouraged.

IV. STAFF AND TRAINING

A. Attention should be given to the provision at all times of adequate medical and technical staff in radiological departments.

B. In sparsely populated areas where radiologists or radiographers are not available, training in the safe use of equipment should be given to the general practitioners or nurses who have to carry out any minor X-ray examinations.

C. Adequate instruction should be given in the medical and dental undergraduate curricula on the uses and hazards of ionizing radiations.

V. SURVEILLANCE

The genetic dose to the population from diagnostic and therapeutic radiology should be kept under effective review by the Health Departments.

Summation of the Results of the Radiological Surveys

The results of the radiological surveys made by the Committee are collected together in table 4 where the annual genetic doses are given in milliroentgens per head of population. The accuracy is indicated by an estimated error in the same units. "The annual genetic dose from general diagnostic radiology (14.1 mr) is less than was estimated in the Medical Research Council's report of 1956, but still contributes the major fraction of the total genetic dose from the medical use of ionizing radiations. The genetic dose from the uses of radiotherapy, excluding radioactive isotopes, in non-malignant conditions (4.5 mr) stands next in order of magnitude, followed by the contribution from the radiotherapy of malignant disease, excluding radioactive isotopes (0.5 mr). The use of radioactive isotopes (0.18 mr), mass miniature radiography (0.01 mr), and dental radiography (0.01 mr) make almost negligible contributions on the total genetic dose. The final total, which is now estimated to be 19.3 mr. per person per year, is smaller than that attributed to diagnostic radiology alone in the Medical Research Council's report (22 mr). This national survey of radiological practice therefore shows the genetic dose in this country to be of the same order of magnitude as that previously deduced and not several times greater as was at one time thought to be possible."

TABLE 4.—SUMMATION OF GENETIC DOSES FROM ALL MEDICAL USES OF IONIZING RADIATION, 1957

[Annual genetic doses in milliroentgens per person]

Medical use	Dose	Estimated error
General diagnostic radiology	14.07	1.00
Mass miniature radiography	0.01	0.01
Dental radiography	0.01	0.01
Radiotherapy:		
External		
Non-malignant disease	4.47	1.20
Malignant disease	0.52	0.25
Internal		
Non-malignant disease	0.13	0.13
Malignant disease	0.05	0.05
Total annual genetic dose	19.3	1.6

"We do not believe that the levels indicated show any need for major restrictions in radiological practice, and we are convinced that the number and type of examinations or treatments must be dictated by the clinical needs of the patients. A dose to the gonads from any X-ray examination is small in comparison to that considered by the Medical Research Council to be acceptable to the individual without causing any undue concern on behalf of himself or his offspring."

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission submits to the Public Health Service quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 17 AEC installations have appeared in *Radiological Health Data*, Volume I, Numbers 8 and 9; and Volume II, Numbers 1 through 10. Summaries follow for Rocky Flats Plant and Feed Materials Production Facility, third and fourth quarters of 1960 and first and second quarters of 1961. Also included are data from monitoring activities around the Nevada Test Site, taken in conjunction with the resumption of underground weapons testing by the Atomic Energy Commission.

The measured concentrations of radioactive substances in air and water may be compared with the Maximum Permissible Concentration (MPC) of that substance as recommended by the National Committee on Radiation Protection and Measurements (NCRP). For the general population, the applicable MPC's are one-tenth of the occupational values for continuous exposure as given in National Bureau of Standards Handbook Number 69.

Feed Materials Production Facilities

Malinckrodt Chemical Works, Uranium Division
Weldon Spring, Missouri

Environmental levels of radioactivity at the Feed Materials Production Facilities (FMPF), Weldon Spring, Missouri, (formerly called the Weldon Spring Plant) for 1959 and first quarter of 1960 were reported in *Radiological Health Data*, Volume 1, Number 8. The following report presents a summary of the data for the third and fourth quarters of 1960 and the first and second quarters of 1961. A summarizing review of comparative data for the period from 1959 through the second quarter 1961 is presented in table 3.

Because the primary feed material for the FMPF is natural uranium ore concentrates, off-site environmental releases from the operations are measured in terms of uranium content. The units of conentration are in terms of the "curie of recently extracted uranium" as defined in NBS Handbook 69, page 14.

Besides the plant site, FMPF also maintains two storage sites located adjacent to the Lambert-St. Louis Municipal Airport and at a quarry near the Missouri River, as shown in figure 1.

Air Monitoring

Monthly air samples are collected on-site along the plant perimeter and on building roofs by six high volume sampling pumps. During the first and second quarters of 1961, monthly samples were also collected by three windmill sampling pumps located south-southwest, west, and north-northwest of the plant. Semiannual air samples are collected at four points on the perimeter of the airport storage site, and monthly air samples were begun during the first quarter of 1961 at the south edge of the quarry. The data obtained from the air monitoring program for the three sites are tabulated in table 1.

Water Monitoring

Process chemical wastes and other process residues are permanently retained in storage facilities located at the site. The plant process sewer, which carries the remaining water effluent from the operations into the Missouri River, is automatically sampled daily to permit

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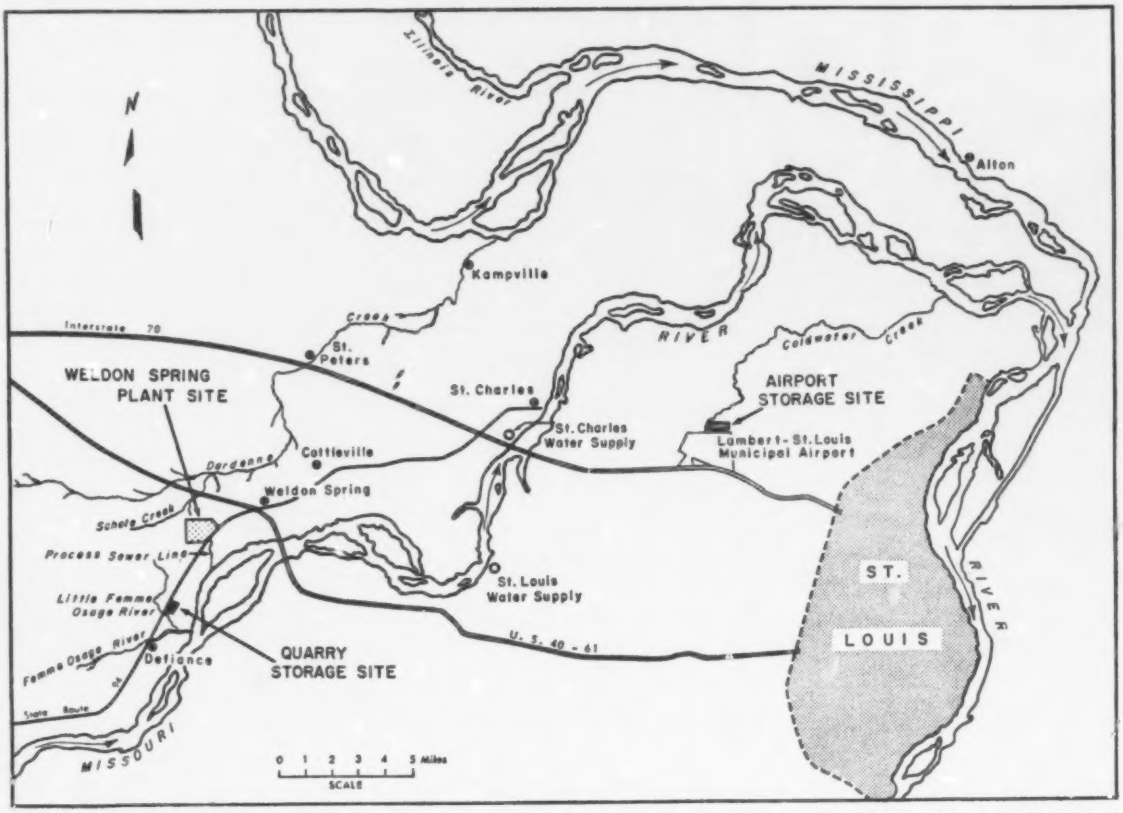
N
Illinois River
MISSISSIPPI
Alton
Kampville
Creek
Interstate 70
St. Peters
WELDON SPRING
PLANT SITE
St. Charles
RIVER
Coldwater Creek
AIRPORT
STORAGE SITE
St. Charles
Water Supply
Lambert-St. Louis
Municipal Airport
Dardenne
Cottleville
Weldon Spring
Schote Creek
Process Sewer Line
Little Femme
Osage River
Femme Osage River
Defiance
QUARRY
STORAGE SITE
St. Louis
Water Supply
U. S. 40 - 61
ST.
LOUIS
RIVER
State Route 94
MISSOURI
0 1 2 3 4 5 Miles
SCALE

Figure 1—LOCATION OF FEED MATERIALS PRODUCTION FACILITIES, WELDON SPRING, MISSOURI

Table 1.—URANIUM CONCENTRATIONS IN AIR

[Average uranium concentrations in $\mu\mu c/m^3$]

On-site sample location			Third quarter 1960		Fourth quarter 1960		First quarter 1961		Second quarter 1961	
Site	Position	Direction from plant	Number of samples	Uranium concentration	Number of samples	Uranium concentration	Number of samples	Uranium concentration	Number of samples	Uranium concentration
Plant	Fence line	Northeast	4	0.027	2	0.196	2	0.24	3	0.011
	Roof	East	4	0.090	2	0.127	3	0.54	3	0.083
	Fence line	North	4	0.020	2	0.155	2	0.67	3	0.130
	Roof	Northwest	4	0.029	2	0.009	3	0.57	3	0.012
	Open area	Southwest	4	0.057	2	0.006	2	0.43	3	0.070
	Roof	Southeast	4	0.437	2	0.260	3	2.22	3	0.107
	Not reported	South-southwest	0		0		1	0.23	3	0.030
	Not reported	West	0		0		2	0.18	3	0.114
	Not reported	North-northwest	0		0		1	0.28	3	0.069
	Average			0.110		0.124		0.700		0.064
Quarry	Edge of quarry	South	0		0		1	0.055	3	0.034
Airport	4 locations	3 North, 1 South	0		6	0.019	0		0	

continual measurement of any release of uranium-bearing materials into the river.

Monthly off-site water samples are collected from lakes and streams located within the plant's watershed, upstream and downstream points on the Missouri River, and streams in the quarry storage site area. Water samples were collected from the environment of the airport storage site during the fourth quarter 1960. The data obtained from the FMPF water monitoring program are presented in table 2.

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TABLE 2.—URANIUM CONCENTRATIONS IN WATER

[Average concentrations in $\mu\mu c$/liter]

Sampling locations	Third quarter 1960		Fourth quarter 1960		First quarter 1961		Second quarter 1961	
	Number of samples	Uranium concentration	Number of samples	Uranium concentration	Number of samples	Uranium concentration	Number of samples	Uranium concentration
Process sewer, plant site	63	860	38	1,150	48	350	60	210
Missouri River sampling points:								
Defiance, upstream	3	9	3	9	3	6	3	2
Femme Osage junction, upstream	3	2	3	4	3	4	3	5
Process sewer outfall	3	360	3	710	3	620	3	160
U. S. Highway 40-61, north side	3	8	3	3	3	4	3	2
U. S. Highway 40-61, south side	3	2	3	2	3	3	3	2
St. Louis City water plant intake	3	2	3	2	3	2	3	2
St. Charles City water plant intake	3	2	3	2	3	2	3	2
Plant off-site sampling points:								
Lake, each of plant	3	1	3	1	3	3	3	2
Lake, north of plant	3	2	3	3	3	4	3	2
Lake, west of plant	3	2	3	1	3	1	3	2
Dardene Creek, upstream	3	5	3	1	3	4	3	2
Dardene Creek, Cottleville	3	8	3	6	3	5	3	3
Dardene Creek, St. Peters	2	5	3	4	3	6	3	4
Dardene Creek, Kampville	3	12	3	2	3	6	3	2
Schote Creek, upstream	3	9	3	3	3	2	3	2
Schote Creek, downstream	3	15	3	13	3	28	3	21
Plant surface drainage, west	3	64	3	96	3	580	3	190
Plant surface drainage, north	3	330	3	420	3	700	3	150
Quarry off-site sampling points:								
Little Femme Osage (LFO), ¼ mile upstream	0		1	1	3	6	3	2
Branch, LFO, ¼ mile upstream	0		1	1	3	1	3	1
LFO, at quarry discharge culvert	0		1	2	3	4	3	3
LFO, ¼ mile downstream	0		1	1	3	2	3	7
LFO, 1¼ mile downstream	0		1	1	3	1	3	4
Airport off-site sampling points:								
Cold Water Creek, adjacent to site	0		3	46	0		0	
Drainage ditch, north of site	0		1	80	0		0	

TABLE 3.—REVIEW OF URANIUM CONCENTRATIONS IN THE ENVIRONMENT OF FMPF, WELDON SPRING, MISSOURI, 1959–JUNE 1961

[Average concentrations in percent of appropriate MPC's][1]

Source of possible contamination	Sampling type and location	Calendar year 1959	Calendar year 1960	1960				1961	
				First quarter	Second quarter	Third quarter	Fourth quarter	First quarter	Second quarter
Plant site	Air plant perimeter	6.0	9.6	22.0	4.9	5.5	6.2	35.0	3.2
	Water, process sewer	1.5	4.2	2.4	3.3	4.3	5.7	1.8	1.0
	Water, Missouri River downstream	0.21	0.22	0.10	0.35	0.31	0.21	0.33	0.16
	Water, streams and ditches	0.25	0.33	0.36	0.38	0.27	0.30	0.84	0.24
	Water, lakes	0.12	0.11	0.21	0.21	0.01	0.01	0.01	0.01
Quarry storage site	Air, south edge	---------	---------	---------	---------	---------	---------	2.7	1.7
	Water, streams	---------	0.02	---------	---------	---------	0.02	0.02	0.02
Airport storage site	Air, site perimeter	21.5	0.78	---------	0.60	---------	0.95	---------	---------
	Water, streams and ditches	1.4	0.15	---------	0.19	---------	0.12	---------	---------

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[1] Environmental MPC's for uranium as given in NBS Handbook 69, page 86, are 2 $\mu\mu c/m^3$ for air and 20 $\mu\mu c$/liter for water.

Rocky Flats Plant

Dow Chemical Company
Denver, Colorado
—Issued September 1961

Introduction

The Rocky Flats Plant is engaged in plutonium fuel element fabrication under contract to the Atomic Energy Commission. The following report presents data showing the environmental levels of radioactivity for the third and fourth quarters of 1960 and first and second quarters of 1961.

To assure proper control of the release of radioactive materials to the environment,

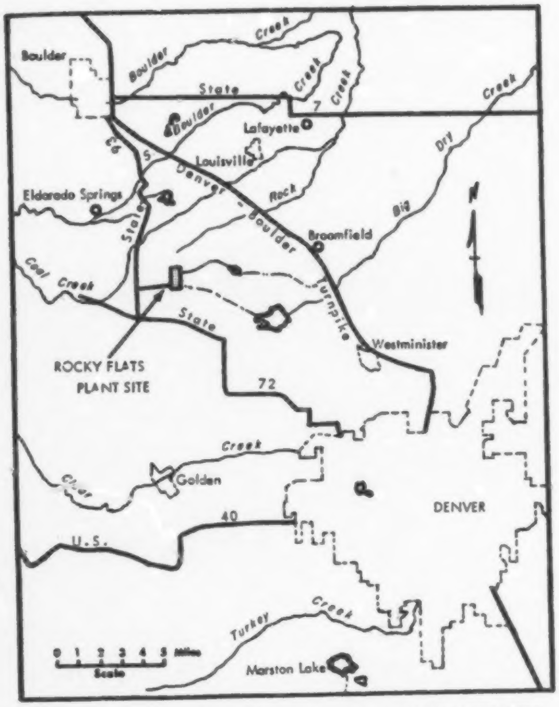
Boulder
Boulder
Creek
State
Boulder
Creek
7
Creek
Creek
Lafayette
Louisville
5
Denver
Boulder
Turnpike
Dry
Big
Rock
Eldorado Springs
State
Broomfield
Coal Creek
State
Westminister
ROCKY FLATS
PLANT SITE
72
Creek
Clear
Golden
DENVER
40
U.S.
Turkey
Creek
0 1 2 3 4 5 Miles
Scale
Marston Lake
N

FIGURE 2.—LOCATION OF THE ROCKY FLATS PLANT ENVIRONMENT, DENVER, COLORADO

water, air, and vegetation are sampled periodically and analyzed for gross alpha activity. The levels encountered have been low enough to make specific identification of the nuclides unnecessary. On occasion, when analysis was made, most of the activity was shown to be uranium.

Airborne Particulates

Airborne particulates are collected on filters for 24 hour sampling periods. Before analysis, the samples are stored until virtually all the short-lived daughter products of radon-220 and radon-222 have decayed. During third and fourth quarters 1960, all samples were collected at a location about three miles west of the plant site. During the second quarter 1961, 146 samples were collected at nine different locations as shown in figure 2. Monthly averages of both alpha and beta activities are presented in table 4.

TABLE 4.—LONG-LIVED RADIOACTIVITY IN AIR

[Average concentrations in μμc/m³]

Period	Gross alpha	Gross beta
Third quarter, 1960:		
July	<0.005	<0.047
August	<0.001	<0.165
September	<0.012	<0.192
Fourth quarter, 1960:		
October	<0.012	<0.325
November	<0.011	<0.310
December	<0.011	<0.310
First quarter, 1961:		
January	<0.010	<0.128
February	<0.013	<0.142
March	<0.010	<0.102
Second quarter, 1961:		
April	<0.009	<0.069
May	<0.010	<0.10
June	<0.026	<0.11

Raw Surface Water

Spot water samples were taken from various streams and lakes within a radius of about 15 miles of the plant. During the first and second quarters, sampling was limited to important water supplies. Sampling locations are shown in figure 2. There is no evidence that the alpha activity observed is greater than that occurring naturally in the area. The resulting data are presented in table 5.

TABLE 5.—UNIDENTIFIED ALPHA ACTIVITY IN RAW SURFACE WATERS

Period	Number of sampling points	Number of samples	Average alpha activity (μμc/liter)
Third quarter, 1960	36	64	<1.1
Fourth quarter, 1960	36	68	<1.0
First quarter, 1961	4	22	<1.5
Second quarter, 1961	4	12	<1.1

Vegetation

During the growing season of 1960, samples of vegetation were collected and stored for analysis at a more convenient time. The samples were analyzed for gross alpha activity during the fourth quarter, 1960 and first and second quarters, 1961. The average concentrations are given in table 6 in terms of micromicrocuries per kilogram dry weight. Two samples containing 1044 and 1182 μμc/kg, analyzed during second quarter 1961, were discarded as statistically invalid in computing the averages. The analyses of the vegetation samples yield no evidence of any escape of radioactive materials to the environment.

TABLE 6.—GROSS ALPHA ACTIVITY IN VEGATATION

Growing season during which sample was collected	Period during which analysis was made	Category	Number of samples	Average concentration ($\mu\mu c$/kg dry)
1951	Not reported		25	86
1960	Fourth quarter, 1960	Water vegetation	16	76
		Land vegetation	14	82
		(Not specified)	28	70
		Total	58	75
1960	First quarter, 1961	Distance from plant:		
		<3 miles	168	50
		3–18 miles	132	59
		100 miles	1	50
1960	Second quarter 1961	<3 miles	444	64 (σ = 50)
		3–18 miles	389	73 (σ = 62)

Nevada Test Site

Atomic Energy Commission

The Atomic Energy Commission is conducting routine radiological monitoring operations in the vicinity of the Nevada Test Site during its current testing activities, as it has during previous test series. The monitoring activities include the operation of portable survey meters, and air samplers which draw air through filter paper, and the placement of film badges at various locations. The results are being made available to the public, as has been the case for past tests.

Although current United States testing activities are underground, radiological monitoring is being conducted because of the possibility that small amounts of radioactivity could be released to the surface through the tunnel mouth or through vents created by a detonation. This has occurred in certain previous underground detonations. Such releases comprise only a very small fraction of the radioactivity produced, and the radioactivity does not extend over a large area.

The low yield explosions conducted during September were contained underground. However, a short time after the detonation of September 15, 1961 there was a brief release of steam from the tunnel mouth, following which low levels of radioactivity were detected in the vicinity of the Test Site. Data accumulated off-site are reported in tables 7 and 8.

These measurements show that more than 99 percent of this radioactivity was due to drifting gases which had escaped with much less difficulty than the solid products that predominate at the source of the explosion. It has been estimated that the amount of radioactive material that will ultimately be deposited off-site from this low yield underground test is less than one hundred-thousandth (0.00001) of that resulting from an equivalent, low-level atmospheric test.

Public Health Service personnel, who conduct the monitoring under an arrangement

TABLE 7.—EXTERNAL GAMMA LEVELS[a]

[Dose-rate in mr/hr]

Location	Hours after shot time	Dose-rate[b]
A ranch—east of Warm Springs, Nev	3.3	12.5
	4.1	1.2
	4.8	0.5
	6.3	0.07
Highway—northeast of Warm Springs, Nev.[c]	3.4	[d] 14.0
Highway—southeast of Warm Springs, Nev.[c]	2.5	0.12
Warm Springs, Nev	5.0	0.2

[a] Resulting almost entirely from passing of the radioactive gases.

[b] As the table indicates, these radiation levels were of brief duration. The maximum exposure any resident could have received would not exceed 18 milliroentgens total. Background radiation for this region of the country is about 200 milliroentgens per year.

[c] Non-populated area.

[d] Highest recorded reading off-site.

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TABLE 8.—GROSS BETA DETERMINATIONS OF SURFACE AIR

[Concentrations in $\mu\mu c/m^3$]

Location	End of sampling period		Length of sampling period (hr:min)	Counted		Activity at count time
	Date	Time		Date	Time	
Alamo	Sept. 15	2025	12:25	Sept. 16	0203	1.3
	Sept. 16	1530	31:30	Sept. 16	2030	5.7
Beatty	Sept. 15	2015	9:45	Sept. 15	2333	2.6
	Sept. 16	2100	23:35	Sept. 16	2206	2.4
Goldfield	Sept. 15	1910	8:40	Sept. 15	2342	3.2
	Sept. 16	1945	24:30	Sept. 16	2202	2.5
Gunderson Ranch	Sept. 15	1800	7:25	Sept. 16	0200	1.5
	Sept. 16	1725	5:10	Sept. 16	2030	4.1
Hiko	Sept. 15	1930	9:45	Sept. 16	0210	2.5
	Sept. 16	1610	6:25	Sept. 16	2035	1.0
Lathrop Wells	Sept. 15	2050	20:20	Sept. 15	2330	3.0
	Sept. 16	2130	24:30	Sept. 16	2041	3.2
Mercury	Sept. 16	0815	24:00	Sept. 16	1500	2.6
Tonopah	Sept. 15	1810	7:40	Sept. 15	2335	2.3
	Sept. 16	1915	25:05	Sept. 16	2050	2.0
Warm Springs	Sept. 15	1605	52:35	Sept. 15	2000	6.8
	Sept. 16	1600	23:50	Sept. 16	2200	1.3

with the AEC, have estimated that in any inhabited area in the vicinity of the Test Site, the maximum exposure that any resident could have received was minute—not exceeding 18 milliroentgens.

The 18 milliroentgens may be compared to an average exposure in that general area of about 200 milliroentgens each year from natural background radiation.

The filters from the air samplers were counted shortly after removal from the collector to obtain an early estimate of the activity. In doing so, some natural radioactive materials were still present [daughters of radon (Ra^{222}) and thoron (Ra^{220})] that would give higher than the correct readings. Upon recounting the filters five days later, the activities on most of the filters were down to background values (less than one micromicrocurie per cubic meter).

ANNOUNCED RUSSIAN NUCLEAR DETONATIONS

Radiological Health Data, Volume II, Number 10 published the dates of the Union of Soviet Socialist Republics announced nuclear detonations through October 3, 1961. The following table gives information on subsequent tests through November 2, 1961. Low yield range has been announced as meaning about a nominal (20 kiloton) yield; low-intermediate to mean between a nominal and one megaton yield.

Test number	Location	Date	Size	Type of test
17	Novaya-Semlya	October 4	Several megaton	Atmospheric.
18	Novaya-Semlya	October 6	Several megaton	Atmospheric.
19	Novaya-Semlya	October 8	Low yield	Atmospheric.
20	Semiplatinsk	October 12	Low to intermediate yield	Atmospheric.
21	Novaya-Semlya	October 20	Several megaton	Atmospheric.
22	Novaya-Semlya	October 23	25 megaton	Atmospheric.
23	South of Novaya-Semlya	October 23	Low yield	Underwater.
24	Novaya-Semlya	October 25	Intermediate to high yield	Atmospheric.
25	Novaya-Semlya	October 27	Low to intermediate yield	Atmospheric.
26	Novaya-Semlya	October 30	50 megaton	Atmospheric (about 12,000 feet).
27	Novaya-Semlya	October 31	Several megaton	Atmospheric.
28	Novaya-Semlya	October 31	Intermediate to high yield	Atmospheric.
29	Novaya-Semlya	November 2	Low to intermediate yield	Atmospheric.
30	Novaya-Semlya	November 2	Low to intermediate yield	Atmospheric.

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SECTION I.—AIR

Radiation Surveillance Network

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network was established in 1956 in cooperation with the Atomic Energy Commission to provide a means of promptly determining increases in levels of environmental radioactivity due to fallout from nuclear weapons tests. During the period reported it consisted of 45 stations at urban locations (see figure 1) operated by State and local health department personnel with 2 of the stations operated by Public Health Service personnel. The Network was expanded during September 1961, following the resumption of nuclear weapons testing in the atmosphere by the USSR.

Measurements of gross beta radioactivity in air are taken because they provide one of the earliest and most sensitive indications of increases of activity in the environment and thus act as an "alert" system. A direct evaluation of biological hazards is not possible from these data alone. Field measurements enable the operator to estimate the amount of beta activity of particulates in air at the station five hours after collection by comparison with a known source using a portable survey meter. The filters are then forwarded to the central laboratory of the Radiation Surveillance Network in Washington, D.C., for a more refined measurement using a thin window proportional counter. The station located at Atlanta, Georgia, conducts its own laboratory analyses.

During August 1961, air samplers were in operation at the 44 stations on an average of 70 percent of the week. Following the resumption of nuclear weapons testing in September, the Network was expanded to 49 stations, operating on a 7-day week. Air is drawn through a cellulose carbon-loaded dust filter using a high volume air sampler. The radioactive material in fallout adhering to small particles is retained on the filter. Some gaseous fission products are adsorbed by the carbon. The contribution by gaseous fission products has represented only a small part of the total beta activity in these samples.

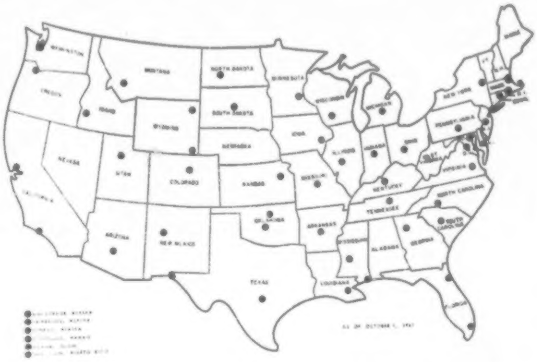
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MISSISSIPPI
MICHIGAN
INDIANA
KENTUCKY
TENNESSEE
ALABAMA
OHIO
GEORGIA
FLORIDA
WEST VIRGINIA
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
PENNSYLVANIA
NEW YORK
VT.
N.H.
MAINE
R.I.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

The average values for August 1961 as pre-

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sented in table 1 are generally below limits of detection by present instrumentation. Table 2 presents the average values for the 49 stations operated during September 1961. These values reflect the increase in the air levels attributable to atmospheric weapons testing.

As a result of the resumption of atmospheric nuclear weapons testing, the results of field measurements of gross beta radioactivity in surface air at RSN stations showing increased readings have been released by the Public Health Service and published almost daily by newspapers. Table 3 presents confirmed daily laboratory results for the period October 1-31, 1961 for stations selected to provide geographical coverage.

TABLE 1.—RADIOACTIVITY OF PARTICULATES IN AIR, AUGUST 1961 GROSS BETA DETERMINATIONS

Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)	Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)
City	State					City	State				
Anchorage	Alaska	23	<0.10	<0.10	<0.10	Minneapolis	Minnesota	8	0.21	<0.10	<0.10
Fairbanks	Alaska	23	0.12	<0.10	<0.10	Pascagoula	Mississippi	18	0.12	<0.10	<0.10
Juneau	Alaska	21	<0.10	<0.10	<0.10	Jefferson City	Missouri	24	0.11	<0.10	<0.10
Phoenix	Arizona	7	<0.10	<0.10	<0.10	Helena	Montana	23	0.11	<0.10	<0.10
Little Rock	Arkansas	22	<0.10	<0.10	<0.10	Trenton	New Jersey	15	0.13	<0.10	<0.10
Berkeley	California	23	<0.10	<0.10	<0.10	Santa Fe	New Mexico	18	<0.10	<0.10	<0.10
Los Angeles	California	22	<0.10	<0.10	<0.10	Albany	New York	29	0.24	<0.10	<0.12
Denver	Colorado	3	<0.10	<0.10	<0.10	Gastonia	North Carolina	23	0.17	<0.10	<0.11
Hartford	Connecticut	29	0.16	<0.10	<0.10	Oklahoma City	Oklahoma	22	0.20	<0.10	<0.11
Washington	District of Columbia	20	0.12	<0.10	<0.11	Ponca City	Oklahoma	24	<0.10	<0.10	<0.10
Jacksonville	Florida	22	<0.10	<0.10	<0.10	Portland	Oregon	23	0.17	<0.10	<0.10
Atlanta	Georgia	11	<0.10	<0.10	<0.10	Harrisburg	Pennsylvania	21	0.15	<0.10	<0.10
Honolulu	Hawaii	23	<0.10	<0.10	<0.10	Providence	Rhode Island	21	0.17	<0.10	<0.10
Boise	Idaho	6	0.12	<0.10	<0.11	Columbia	South Carolina	7	0.13	<0.10	<0.10
Springfield	Illinois	3	0.31	<0.10	<0.14	Pierre	South Dakota	9	0.19	<0.10	<0.10
Indianapolis	Indiana	28	0.24	<0.10	<0.11	Austin	Texas	21	0.12	<0.10	<0.10
Iowa City	Iowa	23	0.25	<0.10	<0.12	El Paso	Texas	19	0.13	<0.10	<0.10
Topeka	Kansas	24	<0.10	<0.10	<0.10	Salt Lake City	Utah	30	0.18	<0.10	<0.10
New Orleans	Louisiana	2	<0.10	<0.10	<0.10	Richmond	Virginia	23	<0.10	<0.10	<0.10
Baltimore	Maryland	23	0.13	<0.10	<0.10	Seattle	Washington	22	<0.10	<0.10	<0.10
Lawrence	Massachusetts	17	<0.10	<0.10	<0.10	Madison	Wisconsin	26	0.14	<0.10	<0.11
Lansing	Michigan	0	—	—	—	Cheyenne	Wyoming	8	<0.10	<0.10	<0.10

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of th individual sampling times.

TABLE 2.—RADIOACTIVITY OF PARTICULATES IN AIR, SEPTEMBER 1961 GROSS BETA DETERMINATIONS

Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)	Station location		Number samples	Maximum (μμc/m³)	Minimum (μμc/m³)	Average[1] (μμc/m³)
City	State					City	State				
Anchorage	Alaska	27	6.6	<0.1	2.0	Pascagoula	Mississippi	24	561.9	<0.1	42.6
Fairbanks	Alaska	26	4.4	<0.1	1.1	Jefferson City	Missouri	27	584.4	<0.1	37.5
Juneau	Alaska	28	2.9	<0.1	0.7	Helena	Montana	27	12.2	<0.1	2.5
Phoenix	Arizona	25	9.2	<0.1	1.4	Trenton	New Jersey	27	69.8	<0.1	10.2
Little Rock	Arkansas	27	708.8	<0.1	43.9	Santa Fe	New Mexico	30	29.0	<0.1	4.5
Berkeley	California	26	15.9	<0.1	2.9	Albany	New York	30	81.9	<0.1	10.6
Los Angeles	California	30	5.8	<0.1	1.8	Gastonia	North Carolina	27	106.5	<0.1	11.9
Denver	Colorado	26	35.5	<0.1	3.8	Bismarck	North Carolina	17	7.1	0.2	2.6
Hartford	Connecticut	30	74.4	<0.1	7.8	Columbus	Ohio	4	15.8	6.0	9.5
Washington	District of Columbia	30	63.7	<0.1	9.6	Oklahoma City	Oklahoma	28	250.7	<0.1	16.6
Jacksonville	Florida	30	401.2	<0.1	22.1	Ponca City	Oklahoma	30	196.1	<0.1	10.1
Miami	Florida	2	2.7	0.6	1.6	Portland	Oregon	27	10.9	<0.1	2.1
Atlanta	Georgia	27	323.6	<0.1	21.5	Harrisburg	Pennsylvania	27	43.5	<0.1	7.1
Honolulu	Hawaii	27	2.5	<0.1	1.6	Providence	Rhode Island	24	59.9	<0.1	6.7
Boise	Idaho	28	29.6	<0.1	4.8	Columbia	South Carolina	25	799.2	<0.1	20.7
Springfield	Illinois	27	296.3	<0.1	17.8	Pierre	South Dakota	25	7.2	<0.1	14.9
Indianapolis	Indiana	29	56.5	<0.1	12.0	Nashville	Tennessee	15	160.6	0.5	40.6
Iowa City	Iowa	30	372.9	<0.1	23.0	Austin	Texas	30	155.0	<0.1	12.0
Topeka	Kansas	28	302.3	<0.1	23.2	El Paso	Texas	30	6.7	<0.1	1.2
Frankfort	Kentucky	10	47.3	2.6	13.0	Salt Lake City	Utah	30	24.8	<0.1	4.7
New Orleans	Louisiana	28	503.3	<0.1	32.0	Richmond	Virginia	27	101.9	<0.1	9.5
Baltimore	Maryland	27	33.4	<0.1	9.2	Seattle	Washington	26	4.7	<0.1	1.1
Lawrence	Massachusetts	27	48.0	<0.1	4.6	Madison	Wisconsin	26	210.5	<0.1	21.8
Lansing	Michigan	23	166.8	<0.1	18.0	Cheyenne	Wyoming	26	26.1	<0.1	3.2
Minneapolis	Minnesota	25	365.0	<0.1	19.8						

[1] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

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ABLE 3.—DAILY MEASUREMENTS OF FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR AT SELECTED STATIONS, OCTOBER 1–31, 1961

[Concentrations in $\mu\mu c/m^3$]

Station Location	October														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Albany, N. Y	14 [a] (21)	18 (20)	13 (23)	3.2 (17)	7.0 (20)	7.6 (23)	7.3 (36)	9.4 (27)	7.3 (26)	9.4 (26)	7.4 (33)	3.8 (42)	3.8 (29)	5.1 (33)	0.86 (40)
Anchorage, Alaska	2.0 (23)	2.1 (15)	1.3 (19)	2.3 (22)	5.3 (11)	4.1 (16)	4.1 (20)	6.6 (10)	6.8 (17)	7.4 (20)	3.0 (20)	15 (18)	12 (17)	9.4 (15)	3.8 (14)
Austin, Tex	1.5 (19)	2.7 (16)	5.8 (16)	12 (22)	8.5 (21)	12 (28)	12 (23)	12 (18)	4.4 (25)	3.1 (25)	2.9 (26)	4.5 (26)	4.2 (30)	4.6 (27)	[b] NS
Gastonia, N. C	7.5 (23)	23 (17)	19 (18)	2.9 (20)	5.3 (18)	7.9 (22)	6.1 (38)	12 (23)	12 (25)	10 (19)	7.9 (24)	7.4 (41)	5.8 (32)	5.1 (28)	5.8 (27)
Jacksonville, Fla	16 (20)	9.4 (18)	5.9 (20)	6.5 (17)	5.4 (19)	10 (26)	11 (28)	NS	9.9 (25)	11 (22)	7.5 (41)	7.4 (34)	4.6 (30)	0.70 (18)	7.5 (21)
Lansing, Mich	[b] NS	6.7 (24)	20 (17)	18 (11)	14 (20)	11 (31)	12 (31)	2.3 (30)	10 (25)	8.3 (22)	10 (27)	14 (26)	5.2 (26)	2.9 (23)	3.7 (22)
Los Angeles, Calif	8.8 (21)	9.6 (17)	11 (17)	11 (17)	NS	19 (25)	13 (29)	NS	NS	8.7 (28)	7.6 (29)	9.2 (34)	10 (30)	NS	NS
Minneapolis, Minn	7.0 (16)	18 (14)	8.7 (19)	9.5 (18)	14 (19)	4.9 (24)	9.2 (46)	9.1 (27)	5.7 (23)	0.74 (13)	6.5 (20)	2.2 (32)	3.4 (23)	4.1 (22)	5.7 (25)
New Orleans, La	3.7 (17)	1.9 (13)	1.6 (31)	9.9 (19)	9.8 (20)	10 (21)	8.5 (51)	3.5 (22)	5.7 (26)	8.2 (24)	7.5 (31)	7.1 (30)	5.9 (36)	3.6 (34)	9.2 (18)
Salt Lake City, Utah	26 (19)	16 (15)	11 (16)	15 (19)	12 (22)	8.2 (21)	7.9 (37)	6.5 (26)	1.9 (23)	4.2 (19)	5.1 (28)	5.3 (33)	3.2 (18)	1.8 (20)	1.6 (15)
Seattle, Wash	NS	3.6 (15)	8.2 (19)	8.7 (18)	3.7 (19)	NS	2.8 (27)	3.8 (19)	1.9 (29)	NS	2.0 (19)	NS	1.9 (14)	0.2	0.7 (15)
Springfield, Ill	1.5 (20)	19 (21)	13 (17)	13 (18)	13 (25)	11 (21)	16 (12)	11 (31)	NS	7.2 (28)	6.1 (29)	9.0 (26)	8.5 (30)	3.9 (21)	4.7 (25)
Topeka, Kans	1.7 (11)	3.2 (17)	9.7 (22)	18 (20)	12 (20)	11 (23)	12 (33)	9.0 (29)	5.0 (24)	4.6 (25)	6.7 (26)	4.5 (32)	2.6 (28)	4.5 (23)	5.0 (21)
ashington, D. C	18 (19)	23 (21)	18 (17)	5.7 (20)	5.9 (25)	7.6 (21)	8.0 (50)	9.0 (30)	9.5 (29)	12 (22)	6.3 (35)	NS	6.8 (36)	5.8 (28)	6.3 (20)

Station Location	October															
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Albany, N. Y	14 (18)	9.8 (13)	9.6 (17)	7.8 (17)	6.2 (20)	4.3 (19)	6.7 (25)	9.4 (37)	12 (32)	8.7 (38)	6.6 (30)	8.7 (13)	6.5 (19)	8.7 (19)	11 (26)	4.7 (27)
Anchorage, Alaska	2.4 (22)	1.4 (26)	4.6 (20)	4.9 (21)	5.6 (21)	0.64	0.54 (41)	0.93 (20)	1.5 (38)	1.0 (47)	2.0 (43)	1.7 (44)	3.9 (33)	1.9 (16)	3.4 (31)	2.3 (30)
Austin, Tex	14 (23)	20 (20)	22 (18)	8.6 (22)	9.2 (21)	5.3 (28)	5.6 (38)	8.4 (21)	7.9 (26)	7.8 (35)	6.6 (34)	13 (17)	5.2 (28)	3.8 (31)	3.1 (24)	1.3 (29)
Gastonia, N. C	9.4 (29)	8.6 (18)	14 (15)	12 (16)	8.5 (22)	2.2 (32)	4.9 (23)	9.4 (41)	7.7 (23)	5.8 (37)	6.7 (25)	31 (10)	25 (20)	19 (20)	18 (20)	9.5 (20)
Jacksonville, Fla	12 (23)	21 (17)	17 (16)	22 (15)	NS	13 (23)	NS	1.8	6.6 (23)	7.6 (39)	7.0 (33)	18 (24)	49 (17)	43 (23)	15 (20)	23 (17)
Lansing, Mich	11 (20)	15 (13)	18 (14)	24 (15)	4.8 (21)	3.4 (40)	2.8 (30)	10 (37)	7.5 (30)	7.1 (26)	9.8 (16)	5.0 (18)	16 (22)	19 (31)	12 (29)	6.2 (17)
Los Angeles, Calif	2.9 (28)	1.9 (24)	1.5 (30)	2.6 (22)	2.4 (27)	2.0 (33)	7.3 (23)	12 (15)	18 (18)	18 (24)	NS	14 (23)	9.5 (25)	18 (18)	7.2 (22)	8.6 (26)
Minneapolis, Minn	2.9 (20)	3.8 (20)	7.1 (18)	4.0 (18)	2.8 (21)	3.1 (18)	4.5 (24)	4.9 (17)	7.8 (16)	11 (22)	2.2 (29)	3.3 (23)	6.0 (32)	5.9 (26)	5.9 (15)	6.0 (19)
New Orleans, La	14 (24)	14 (18)	6.9 (23)	3.6 (35)	6.8 (24)	6.4 (24)	2.5 (32)	2.6 (32)	2.1 (28)	1.6 (43)	4.6 (26)	14 (24)	26 (22)	12 (25)	3.9 (27)	8.4 (26)
Salt Lake City, Utah	1.3 (30)	1.9 (27)	6.4 (13)	38 (12)	15 (14)	5.3 (17)	2.3 (12)	5.2 (26)	9.7 (23)	15 (18)	10 (25)	16 (14)	8.4 (17)	2.4 (13)	3.4 (23)	4.9 (27)
Seattle, Wash	1.5 (25)	4.2 (30)	3.1 (30)	4.2 (25)	2.7 (23)	2.2 (23)	2.3 (20)	1.0 (23)	2.7 (30)	NS	4.6 (15)	2.4 (25)	3.3 (19)	1.4 (37)	2.2 (15)	2.2 (25)
Springfield, Ill	6.1 (21)	8.4 (19)	13 (17)	11 (20)	3.8 (20)	1.8 (35)	1.9 (25)	2.4 (43)	2.7 (22)	3.1 (31)	15 (14)	4.3 (24)	12 (17)	19 (21)	13 (28)	1.9 (21)
Topeka, Kans	5.2 (20)	23 (11)	22 (18)	4.6 (20)	4.6 (23)	8.6 (23)	8.2 (43)	9.1 (24)	9.1 (28)	9.4 (22)	6.0 (41)	10 (16)	7.6 (26)	6.2 (21)	1.7 (33)	1.3 (17)
Washington, D. C	4.4 (20)	8.2 (16)	15 (17)	11 (18)	9.6 (21)	7.9 (11)	5.2 (23)	8.2 (37)	5.1 (25)	3.9 (31)	8.8 (18)	3.5 (21)	2.6 (15)	10 (23)	10 (26)	4.9 (26)

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[a] Figures in parentheses denote age of fission products in days.
[b] NS—No sample received (i.e., motor, power or filter failure).

Surface Air Radon, Thoron, and Fission Product Gross Beta Concentrations at Cincinnati, Ohio

Robert A. Taft Sanitary Engineering Center, Public Health Service

Natural background radioactivity in our atmosphere is an important public health consideration because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artificially produced radionuclides. Natural radioactivity in surface air is attributed to a number of unstable nuclides other than those produced by man. The earth's crust contains trace amounts of uranium and thorium that occur naturally and which decay through a series of their daughter products. These decay products of uranium and thorium are introduced into surface air through their rare gas daughters, radon (radon-222) and thoron (radon-220), which in turn continue to decay through the uranium and thorium series, respectively. The radon and thoron content of air depends on the escape of these rare radioactive gases from the earth. Concentrations depend on prevailing atmospheric conditions such as ambient temperature, humidity, and pressure, and on soil conditions such as moisture, porosity and temperature.

Most of the natural radioactivity in surface air is due to radon (Rn^{222}) and its daughters. Thoron (Rn^{220}) and its daughters contribute much less because of thoron's short half-life and hence, a lower diffusion rate from the soil.

Radiological Health Research Activities, Research Branch, Division of Radiological Health, Public Health Service, performs a continuous daily sampling program for radon (Rn^{222}), thoron (Rn^{220}), and gross beta fission product concentrations in surface air. The gross beta activity of atmospheric particulates, when measured several days after sample collection, is principally due to artificially produced radionuclides.

Radon-222 concentrations are determined from alpha measurements made immediately after the sampling period (24 to 72 hours) has ceased. Radon-222 (a.m.) concentrations have been corrected for any radon-220 daughter interferences. Radon-222 (p.m.) concentrations are derived from alpha measurements made in the afternoon (3 p.m.) approximately 7 hours after the new sampling period has begun. These values are from the same filters that are counted at 8 a.m. the following day. Radon-222 (p.m.) concentrations are uncorrected for any radon-220 daughter interferences. Radon-220 concentrations are determined from alpha measurements made on the sample used to evaluate the corrected radon-222 (a.m.) concentrations, but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter holder.

The data are computed by an electronic data processing system which is programmed for thirteen four-week periods per calendar year. The data for the period August 14-September 8, 1961, appears in table 1.

REFERENCE

Setter, L. R. and Coats, G. I., "The Determination of Airborne Radioactivity," *American Industrial Hygiene Association Journal*, Vol. 22, No. 1, Feb. 1961.

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TABLE 1.—SURFACE AIR RADON (Rn^{222}), THORON (Rn^{220}), AND FISSION PRODUCT GROSS BETA CONCENTRATIONS, AUGUST 14–SEPTEMBER 8, 1961

End of sampling period		Continuous sample collection			Rn^{222} 8 a.m. ($\mu\mu c/m^3$)	Rn^{222} 3 p.m. ($\mu\mu c/m^3$)	Rn^{220} ($\mu\mu c/m^3$)	Beta activity ($\mu\mu c/m^3$)
		Sample change time	Sample period (hours)	Volume (m^3)				
August	14	0810	72.0	86.3	630	190	7.6	0.08
	15	0820	24.1	29.4	810	190	8.3	0.07
	16	0810	23.8	28.6	1000	180	8.8	0.13
	17	0809	23.9	28.3	860	170	8.1	0.11
	18	0809	24.0	27.7	890	220	6.9	0.18
	21	0810	72.0	82.2	470	230	4.9	0.05
	22	0815	24.0	28.3	540	190	6.5	0.09
	23	0815	24.0	28.3	500	280	5.7	0.06
	24	0815	24.0	27.8	400	130	3.6	0.02
	25	0815	24.0	27.8	310	90	2.4	0.05
	28	0808	71.8	82.8	1000	170	9.0	0.06
	29	0806	23.9	27.7	710	220	5.6	0.08
	30	0820	24.2	28.6	710	180	4.7	0.06
	31	0810	23.8	28.4	1000	200	8.5	0.10
September	1	0800	23.8	27.7	200	90	2.8	0.07
	5	0810	96.1	110.2	950	90	10.1	0.01
	6	0800	23.8	27.9	730	180	5.7	<0.01
	7	0806	24.1	29.7	240	130	1.2	0.12
	8	0815	24.1	29.9	420	180	2.7	0.06
Average					660	170	6.0	0.07
Range of counting errors (2σ)								
Maximum					60	30	1.1	0.05
Minimum					25	15	0.4	0.01

Radioactivity Measurements In Air

U.S. Naval Research Laboratory

Radioactivity measurements of air-filter samples collected at various sites near the 80th Meridian (West) are made by the U.S. Naval Research Laboratory under a program partially financed by the Atomic Energy Commission.

The daily record of fission product beta activity during July 1961 is presented in table 1, and the radioactivity profile for the same month and the first and second quarters of 1961 are shown in figure 2. This figure illustrates the data plotted in semilogarithmic coordinates. The abscissa is expressed in micromicrocuries per cubic meter of surface air. The concentrations in table 1 are expressed in disintegrations per minute per cubic meter of air at the collecting site (2.2 disintegrations per minute per cubic meter equals 1 micromicrocurie per cubic meter).

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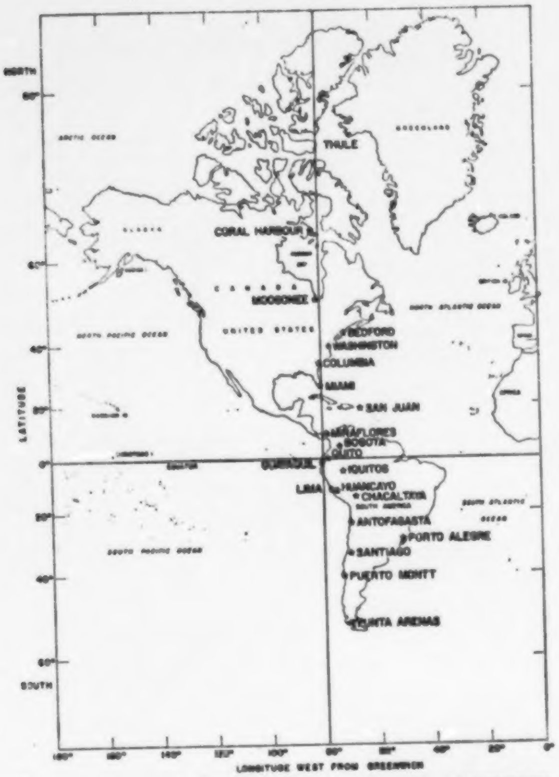
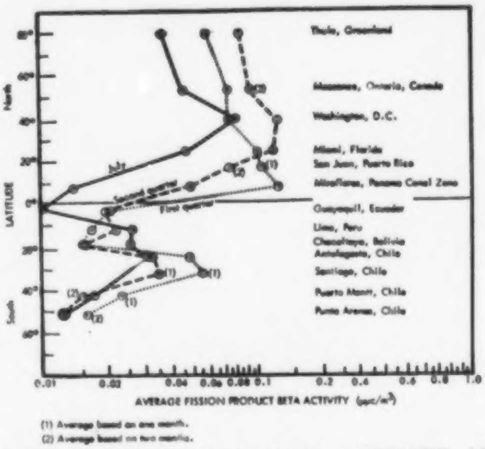

NORTH
SOUTH
LATITUDE
LONGITUDE WEST FROM GREENWICH
ARCTIC OCEAN
GREENLAND
ALASKA
CANADA
UNITED STATES
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
SOUTH AMERICA
THULE
CORAL HARBOUR
MOOSONEE
BEDFORD
WASHINGTON
COLUMBIA
MIAMI
SAN JUAN
MIRAFLORES
BOGOTA
QUITO
GUAYAQUIL
IQUITOS
LIMA
HUANCAYO
CHACALTAYA
ANTOFAGASTA
PORTO ALEGRE
SANTIAGO
PUERTO MONTT
PUNTA ARENAS

Figure 1. — ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (W)



(1) Average based on one month.
(2) Average based on two months.

Figure 2.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR A STATIONS NEAR THE 80TH MERIDIAN (WEST), FIRST QUARTER, SECOND QUARTER AND JULY 1961

Table 1.—DAILY RECORD OF FISSION PRODUCT GROSS BETA ACTIVITY COLLECTED BY AIR FILTRATION, JULY 1961

[Disintegrations/minute per cubic meter]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador	Miraflores, Panama Canal Zone	Miami, Florida	Washington, D. C.	Moosonee, Ontario, Canada	Thule, Greenland
1	0.03	----------	0.04	0.03	----------	----------	0.04	0.08	0.19	0.18	0.02
2	0.03	----------	0.04	0.03	----------	----------	0.04	0.08	0.19	0.18	0.02
3	0.03	----------	0.04	0.03	----------	----------	0.04	0.08	0.19	0.18	0.02
4	0.03	----------	0.06	0.06	----------	0.01	0.02	0.15	0.22	0.09	0.02
5	0.03	----------	0.06	0.06	----------	0.01	0.02	0.15	0.22	0.09	0.08
6	0.02	0.04	0.06	0.06	----------	0.01	0.02	0.15	0.22	0.09	0.08
7	0.02	0.04	0.06	0.06	----------	0.01	0.02	0.15	0.22	0.09	0.08
8	0.05	0.05	0.06	0.06	0.15	0.01	0.02	0.15	0.22	0.90	0.08
9	0.05	0.05	0.06	0.06	0.15	0.01	0.02	0.15	0.22	0.09	0.08
10	0.05	0.05	0.06	0.06	0.15	0.01	0.02	0.15	0.22	0.09	0.08
11	0.06	0.03	0.07	0.09	0.02	0.01	0.03	0.08	0.19	0.10	0.08
12	0.06	0.03	0.07	0.09	0.02	0.01	0.03	0.08	0.19	0.10	0.08
13	0.02	0.01	0.07	0.09	0.02	0.01	0.03	0.08	0.19	0.10	0.06
14	0.02	0.01	0.07	0.09	0.02	0.01	0.03	0.08	0.19	0.10	0.06
15	0.03	0.02	0.07	0.09	0.02	0.01	0.03	0.12	0.19	0.10	0.06
16	0.03	0.02	0.07	0.09	0.02	0.01	0.03	0.12	0.19	0.10	0.06
17	0.03	0.02	0.07	0.09	0.02	0.01	0.03	0.12	0.19	0.10	0.06
18	0.02	0.03	0.09	0.04	0.05	0.01	0.04	0.11	0.15	0.12	0.06
19	0.02	0.03	0.09	0.04	0.05	0.01	0.04	0.11	0.15	0.12	0.12
20	0.02	0.05	0.09	0.04	0.05	0.01	0.04	0.07	0.15	0.12	0.12
21	0.02	0.05	0.09	0.04	0.05	0.01	0.04	0.07	0.15	0.12	0.12
22	0.02	0.02	0.09	0.04	0.05	0.01	0.04	0.07	0.15	0.12	0.12
23	0.02	0.02	0.09	0.04	0.05	0.01	0.04	0.07	0.15	0.12	0.12
24	0.02	0.02	0.09	0.04	0.05	0.01	0.04	0.07	0.15	0.12	0.12
25	0.02	0.03	0.07	0.05	0.07	0.02	0.03	0.09	0.14	0.06	0.12
26	0.02	0.03	0.07	0.05	0.07	0.02	0.03	0.09	0.14	0.06	0.10
27	0.02	0.06	0.07	0.05	0.07	0.02	0.03	0.09	0.14	0.06	0.10
28	0.02	0.06	0.07	0.05	0.07	0.02	0.03	0.09	0.14	0.06	0.10
29	0.02	0.09	0.07	0.05	0.07	0.02	0.03	0.10	0.14	0.06	0.10
30	0.02	0.09	0.07	0.05	0.07	0.02	0.03	0.10	0.14	0.06	0.10
31	0.02	0.09	0.07	0.05	0.07	0.02	0.03	0.10	0.14	0.06	0.10
Mean (dpm/m³)	0.028	0.040	0.069	0.057	0.060	0.012	0.031	0.103	0.176	0.101	0.
Mean (μμc/m³)	0.013	0.018	0.031	0.026	0.027	0.005	0.014	0.046	0.079	0.045	0.0

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Canadian Radioactive Fallout Study Program

Department of National Health and Welfare, Dominion of Canada

As part of its radioactive fallout study program, the Radiation Protection Division, Department of National Health and Welfare, Dominion of Canada, conducts air and precipitation sampling programs.

The nationwide air sampling program is conducted for two main purposes: (1) To provide a convenient method for the early detection of changes in the fission product concentration in the air and therefore of likely changes in the deposition products on the ground, and (2) To obtain data to show the day-to-day and station-to-station variations. This may be useful to meteorologists for obtaining better understanding of the mechanisms involved in radioactive fallout distribution in the atmosphere.

A more detailed discussion of the sampling procedures, methods of analysis, and interpretation of results of the Department's radioactive fallout program is contained in the "Annual Report for 1959", Report Number CNHW (RP-3).

With the permission of the Department of National Health and Welfare, Dominion of Canada, *Radiological Health Data* published data on fission product gross beta activity in air and precipitation in Volume II, Numbers 1, 4, and 8, covering the periods July 1959-June

TABLE 1.—FISSION PRODUCT GROSS BETA RADIOACTIVITY IN AIR, FIRST QUARTER 1961

[Average concentration in $\mu\mu c/m^3$]

Station location	January	February	March
Calgary	0.14	0.10	0.12
Chatham	0.10	0.14	0.12
Coral Harbour	0.11	0.14	0.18
Edmonton	0.12	0.15	0.13
Fort Churchill	0.10	0.13	0.15
Fort William	0.12	0.14	0.16
Fredericton	0.09	0.09	0.13
Goose Bay	0.09	0.13	0.14
Inuvik	0.10	0.12	0.18
Kapuskasing	0.11	0.14	0.17
Montreal	0.10	0.12	0.14
Moosonee	0.10	0.12	0.17
Ottawa	0.11	0.13	0.11
Regina	0.11	0.13	0.13
Resolute	0.06	0.10	0.09
Saskatoon	0.11	0.16	0.14
Shearwater	0.08	0.13	0.10
Torbay	0.07	0.10	0.09
Toronto	0.11	0.12	0.14
Vancouver	0.05	0.03	0.06
Whitehorse	0.13	0.13	0.14
Windsor	0.12	0.13	0.14
Winnipeg	0.15	0.15	0.15
Yellowknife	0.11	0.14	0.16

TABLE 2.—MONTHLY AVERAGE FISSION PRODUCT GROSS BETA CONCENTRATIONS IN AIR, FIRST QUARTER 1961

[Radioactivity in $\mu\mu c/m^3$]

Month	Number of stations operating 50% of the time	Minimum average of all stations	Maximum average of all stations	Overall average
January	24	0.05	0.15	0.10
February	24	0.03	0.16	0.12
March	23	0.06	0.18	0.14

TABLE 3.—FISSION PRODUCT GROSS BETA RADIOACTIVITY IN PRECIPITATION, FIRST QUARTER 1961

Station location	January		February		March	
	$\mu\mu c$/liter	Inches	$\mu\mu c$/liter	Inches	$\mu\mu c$/liter	Inches
Calgary	62.3	0.22	25.1	1.21	381.5	0.16
Chatham	9.1	4.10	15.7	3.38	16.7	4.53
Coral Harbour	153.5	0.21	27.2	0.76	98.8	0.20
Edmonton	22.8	0.34	25.8	0.74	77.5	0.18
Fredericton	18.2	3.29	19.8	3.03	6.1	3.00
Fort Churchill	10.6	0.83	9.9	0.60	10.6	1.63
Fort William	15.2	0.51	trace	1.06	47.1	1.41
Goose Bay	4.6	3.18	3.1	0.61	9.1	1.47
Inivuk	62.3	0.17	48.2	0.49	28.9	0.68
Kapuskasing	30.4	0.76	7.0	2.87	30.4	2.47
Montreal	354.2	[a] 0.03	40.3	1.45	15.2	2.71
Moosonee	6.1	1.00	8.4	1.46	4.6	3.40
Ottawa	24.3	0.57	14.9	2.65	18.2	2.44
Regina	170.4	0.40	14.9	0.57	145.9	0.27
Resolute	----------	[b] NS	----------	NS	----------	NS
Saskatoon	27.4	0.50	84.5	0.38	139.8	0.39
Shearwater	27.4	3.65	----------	NS	13.7	4.24
Torbay	15.2	3.59	16.7	4.03	12.2	8.12
Toronto	45.6	1.11	10.6	3.34	41.6	1.53
Vancouver	4.6	8.30	----------	NS	47.1	4.57
Whitehorse	45.6	0.46	88.0	0.59	18.2	0.67
Windsor	48.6	0.79	23.7	2.90	31.9	2.67
Winnipeg	83.6	0.11	17.5	1.64	141.4	0.53
Yellowknife	12.2	1.55	13.4	0.88	10.6	0.91
Average	54.9	----------	25.7	----------	58.6	----------

[a] January 16-23 only.
[b] NS—No sample.

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1960 and the third and fourth quarters 1960 respectively. Similar data are presented for the first quarter 1961 in tables 1, 2, and 3. Table 4 presents the daily results of gross beta radioactivity in air for the period September 4 to October 15, 1961. The results reflect an increase in the air levels due to the resumption of nuclear weapons testing in the atmosphere.

The overall monthly average levels shown in table 2 are higher than in the previous quarter and apparently increase from month to month in the quarter. This is the usual pattern and is probably associated with meteorological phenomena. The values in table 1, 2, and 4 are in $\mu\mu c/m^3$ whereas previously reported data has been in dpm/m^3.

The results in table 3 show that the overall monthly averages of total beta radioactivity in precipitation are about the same as the previous quarter.

TABLE 4.—DAILY RECORD OF FISSION PRODUCT GROSS BETA RADIOACTIVITY IN AIR, SEPTEMBER 4 TO OCTOBER 15, 1961

[Concentrations in $\mu\mu c/m^3$]

Station location	September																				
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Aklavik	0.05	0.05	0.05	0.14	2.8	0.21	2.5	0.9	0.45	6.8	3.8	0.14	0.45	1.9	7.2	1.6	92.2	45.9	37.4	15.8	21.2
Calgary	0.05	0.37	0.37	0.02	0.38	1.8	2.3	3.5	1.4	0.9	2.4	11.7	32.8	3.4	7.0	9.4	2.7	0.9	5.2	2.0	4.2
Chatham	0.04	0.03	0.03	0.05	0.06	[a]—	1.4	0.5	0.40	0.6	0.04	0.3	74.2	72.0	40.5	49.5	78.8	105.8	105.8	39.2	39.2
Coral Harbour	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Edmonton	0.04	—	0.09	3.4	0.07	3.5	0.12	1.1	0.22	0.09	0.5	7.0	0.7	4.5	4.0	3.1	8.1	2.9	153.0	7.4	2.8
Fort Churchill	0.06	0.06	0.06	0.06	0.07	0.5	0.01	0.04	0.04	0.7	0.8	0.32	8.1	6.3	1.8	3.3	2.5	0.7	7.4	25.6	24.3
Fort William	0.04	0.05	0.05	0.05	0.11	0.12	0.05	0.32	1.0	1.1	0.14	7.4	184.5	55.4	5.4	54.0	270.0	450.0	72.0	3.6	33.8
Fredericton	0.01	0.04	0.04	0.04	—	0.09	0.14	0.36	0.36	0.6	0.09	5.2	87.8	46.8	30.2	82.4	135.0	—	27.0	4.7	20.2
Goose Bay	0.04	0.04	0.04	0.04	0.07	0.06	0.04	2.1	5.6	0.04	0.45	1.4	45.9	19.8	43.6	11.2	11.7	8.6	67.5	54.9	16.6
Kapuskasing	0.09	0.01	0.01	0.09	0.12	0.01	0.12	0.6	0.18	0.09	1.8	—	69.8	155.2	166.5	155.2	155.2	180.0	177.8	44.6	33.8
Montreal	0.09	0.04	0.04	0.04	0.07	0.11	0.13	0.27	0.36	2.6	0.6	0.6	1.1	52.2	45.9	39.2	36.0	157.5	171.0	162.0	42.3
Moosonee	0.05	0.09	0.09	0.09	0.10	—	—	0.36	2.4	1.2	1.4	4.0	85.5	85.5	85.5	99.0	99.0	252.0	148.5	1.3	72.0
Ottawa	0.08	0.07	0.07	0.07	0.14	0.15	0.17	0.18	1.8	0.6	0.22	2.1	56.2	38.2	63.0	34.2	45.0	265.5	227.2	121.5	20.7
Regina	0.03	0.03	0.03	0.05	0.11	0.9	1.3	1.4	8.6	7.6	5.2	5.2	4.3	17.1	18.0	3.3	12.2	9.0	21.6	63.0	49.5
Resolute	—	—	—	—	—	—	—	0.04	0.04	0.45	4.5	—	—	—	—	—	—	—	—	—	—
Saskatoon	0.01	0.01	0.07	0.08	1.1	0.7	—	5.9	18.0	3.2	3.2	4.0	16.4	4.7	3.9	11.7	4.0	32.4	146.2	52.2	0.8
Shearwater	0.06	0.06	0.06	<0.01	0.09	0.08	0.5	0.32	0.14	1.4	0.18	4.1	238.5	86.2	69.3	71.1	37.8	45.0	44.6	16.2	2.0
Torbay	0.04	0.07	0.07	0.07	0.10	0.10	0.12	0.14	0.14	—	0.22	2.0	122.4	—	6.8	25.2	69.8	37.8	18.0	36.0	29.2
Toronto	0.08	0.06	0.06	0.06	0.06	0.13	0.19	0.27	0.36	0.5	0.6	2.2	6.1	319.5	102.6	51.8	40.0	112.5	14.0	126.0	7.9
Vancouver	0.02	0.02	0.02	0.09	0.10	0.09	1.6	3.8	3.1	3.3	3.9	2.2	32.8	3.6	1.2	1.0	1.4	1.8	2.2	1.7	4.7
Whitehorse	0.11	0.03	0.03	0.06	1.1	1.1	3.4	1.9	3.6	3.5	1.3	9.4	0.27	0.6	2.5	1.5	2.4	2.8	2.2	4.5	25.2
Windsor	0.04	0.06	0.06	0.06	0.18	0.20	0.23	0.14	0.40	0.5	0.18	2.6	9.4	117.0	121.5	81.0	32.8	60.8	256.5	27.4	2.8
Winnipeg	0.04	0.04	0.04	0.92	1.2	0.13	0.32	0.09	0.40	0.32	0.9	49.0	26.1	9.9	8.1	2.2	0.04	4.7	28.4	99.0	23.4
Yellowknife	0.04	0.09	0.09	0.06	0.15	0.10	0.15	0.14	1.1	0.5	2.5	9.1	2.9	8.1	2.8	7.1	1.7	81.0	162.0	38.7	21.2
Average	0.05	0.06	0.07	0.25	0.39	0.95	0.73	1.0	2.2	1.7	1.5	6.2	50.3	51.3	38.1	36.3	51.8	88.6	86.3	43.1	22.7

Station location	September						October														
	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Aklavik	0.1	1.0	1.4	1.6	2.4	2.8	6.3	8.6	4.5	3.1	6.3	5.0	6.5	5.0	44.1	4.3	3.2	1.9	2.0	4.5	5.6
Calgary	23.4	9.4	9.4	8.1	7.5	28.8	30.2	25.2	18.7	15.4	34.2	7.6	5.0	10.8	7.3	20.2	2.5	11.7	—	2.3	3.2
Chatham, N. B.	9.0	5.0	4.1	4.5	11.7	4.8	5.4	41.0	83.2	15.3	2.7	63.9	29.7	18.9	10.6	10.0	7.2	17.6	17.6	5.6	17.1
Coral Harbour	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Edmonton	35.6	9.5	9.1	12.6	10.8	9.9	20.0	19.8	20.7	10.8	29.7	14.8	7.4	7.2	18.0	10.4	12.2	10.4	12.6	4.1	4.5
Fort Churchill	—	—	3.2	0.3	1.6	1.0	2.1	8.1	5.6	8.6	0.4	5.7	7.7	8.0	3.3	3.5	17.6	2.1	4.2	36.9	—
Fort William	18.1	12.2	24.3	7.6	21.2	9.0	18.0	40.5	15.5	97.6	21.8	9.9	19.9	18.9	3.2	0.1	13.1	14.1	1.2	3.0	12.8
Fredericton	9.2	3.7	3.0	13.1	33.8	4.7	14.8	77.4	23.8	0.4	16.6	23.4	10.6	11.7	7.3	11.2	12.2	12.6	13.5	16.2	4.5
Goose Bay	5.0	1.4	0.2	4.2	0.9	5.9	5.0	13.5	36.0	4.0	0.9	0.2	3.6	0.8	4.9	3.9	6.3	14.4	0.04	12.4	0.5
Kapuskasing	31.5	16.6	16.6	—	—	—	—	54.0	30.2	24.8	29.7	17.1	31.5	19.8	4.5	4.5	3.4	14.2	0.3	7.2	7.6
Montreal	11.6	8.1	2.9	29.7	7.8	6.1	36.0	41.0	36.9	12.4	25.2	14.0	29.7	25.6	25.4	26.8	8.1	10.8	25.2	15.3	3.5
Moosonee	90.9	11.3	—	—	—	—	18.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ottawa	7.9	4.3	27.9	12.2	11.0	36.9	40.5	8.3	22.5	11.2	18.2	53.1	20.0	24.3	25.2	15.8	9.8	17.1	18.0	39.6	23.9
Regina	12.4	26.6	8.5	15.8	15.8	32.4	37.8	21.2	44.1	28.8	14.0	45.0	30.6	4.1	12.6	9.0	9.2	3.6	8.6	21.6	2.4
Resolute	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Saskatoon	23.9	7.6	16.2	13.5	10.1	26.8	15.3	36.0	35.1	15.3	21.6	15.3	4.1	10.8	9.2	6.3	2.7	4.6	9.4	8.6	2.5
Shearwater	0.8	5.4	5.8	12.6	14.8	4.7	5.8	65.2	13.5	0.8	14.8	18.4	15.8	13.5	6.8	12.2	14.0	22.0	17.6	13.5	7.4
Torbay	2.5	2.1	7.6	5.4	1.6	9.0	4.5	4.6	18.0	13.0	1.4	18.0	44.1	17.6	4.4	10.8	5.4	—	—	—	—
Toronto	5.0	2.2	14.0	19.1	37.4	189.0	29.7	3.4	45.0	20.7	23.4	42.3	24.3	36.9	27.0	22.7	26.8	17.6	10.1	7.6	9.9
Vancouver	8.1	16.2	11.9	10.4	1.7	5.4	13.1	10.4	17.6	—	17.6	22.5	27.0	14.8	12.1	25.0	11.7	13.5	3.8	1.7	2.0
Whitehorse	8.6	3.9	4.0	14.8	14.0	4.0	8.3	10.4	17.6	4.0	5.0	7.2	7.6	5.3	—	10.4	6.8	4.2	29.7	10.8	14.4
Windsor	1.2	7.4	—	15.8	31.5	32.4	9.2	9.0	18.9	15.8	33.3	40.5	19.8	36.0	47.2	36.0	23.4	27.9	9.0	9.0	18.0
Winnipeg	14.0	17.6	10.1	23.4	8.8	45.0	166.5	82.8	18.0	23.4	18.4	14.8	4.7	5.4	6.8	5.6	2.3	2.0	128.2	5.6	9.4
Yellowknife	28.4	13.5	14.4	15.3	14.4	10.8	21.6	13.8	20.8	1.7	3.3	9.4	9.4	7.8	3.6	5.8	2.9	4.2	33.3	16.2	16.2
Average	16.5	8.8	9.7	12.0	12.9	23.5	24.2	28.3	26.5	16.3	16.1	21.3	17.1	14.4	14.2	12.1	9.5	11.3	18.1	12.1	8.7

[a] (—) indicates no sample.

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SECTION II. — FOOD OTHER THAN MILK

Survey of Radioactivity in Food

Food and Drug Administration

The Food and Drug Administration conducts a continuing surveillance to determine the concentrations of certain radionuclides in a variety of different food items, domestic and foreign. The following tabulations present the results of surveillance of foods for strontium-90 and cesium-137. These samples were collected by representatives of Food and Drug Administration Districts.

In table 1 are assembled analyses of vegetables, fruits, nuts, dairy products, grains, and baby foods for cesium-137 with corresponding strontium-90 analyses where available. Although there are numerous exceptions, it appears generally that the cesium-137 level is comparatively higher than the strontium-90 level. However, correlation between these nuclides is very poor and it may be concluded that these results offer little encouragement to the use of the more readily determinable cesium-137 levels as meaningful indicators of strontium-90 levels in foods.

Table 2 gives the results of a survey of 1958 and 1959 tea samples imported from the countries indicated. Each sample represents, on the average, a pooling of about 5 to 10 individually-ashed tea samples. It is to be noted that the Indian, Japanese, and Formosan teas carry the highest levels of strontium-90 and by comparison, the African and South American teas, much lower levels. Of interest is the finding that soluble teas contain very much lower concentrations of strontium-90. This is in general agreement with some laboratory studies which have shown that the beverage prepared from contaminated tea leaves carries over only about 20 percent of the strontium-90.

Table 3 lists 8 categories of foods for which a number of strontium-90 analyses have been completed. Because of the relatively small number of samples originating from the same geographical areas, it is not possible at this time to draw any significant conclusions on this point. Differences between categories, however, are at once apparent as exemplified in the relatively high strontium-90 levels in wheat, and dairy products. With the exception of the dried fruits, the fresh fruits in general contain less strontium-90 than the vegetables do. This difference can also be observed in the baby foods. Of considerable interest are the differences between raw (fresh) and processed foods. Reference should be made to those items identified in the footnotes as originating from the same lot. It is notable that processing causes a considerable removal of strontium-90 from the raw product. Of particular interest is flour originating from contaminated wheat. Here the reduction in strontium-90 content is even greater. But, as has been observed elsewhere, the bran carries an even higher strontium content than the wheat kernel.

Similar FDA data on radioactivity in food were presented in *Radiological Health Data,* Volume II, Numbers 1, 8, and 9.

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TABLE 1.—RADIOANALYSES OF RAW AND PROCESSED FOODS

[Concentrations in $\mu\mu c$/kg original material]

Category	Product	Origin		Date harvested or processed	Cesium-137	Strontium-90
		County or city	State or country			
Vegetables	Snap beans	Rhodedale	Md.	Sept. 7, 1960	7.5	14
	Green beans (canned)	Mercer	Ohio	Sept. 26, 1960	ND[2]	
	Green beans				422	
	Cabbage	Shawnee	Kans.	1960	33	7.1
	Cabbage	Monterey	Calif.	Aug. 29, 1960	7	1.1
	Cabbage	Rogers	Minn.	1960	ND	4.4
	Celery	Van Buren	Mich.	July 14, 1960-Sept. 28, 1960	ND	
	Celery	Imlay City	Mich.	Sept. 26, 1960	ND	
	Celery	Middlesex	Mass.	Sept. 8, 1960	81	
	Carrots (raw)	Wayne	N. J.	Sept. 26, 1960	371	
	Carrots (canned)	Wayne	N. J.	Sept. 26, 1960	6	1.1
	Corn (shelled)	Cranford	Ill.	Oct. 18, 1960[1]	2.2	0.31
	Lettuce	Montgomery	Md.	Spring 1960	<5	2.6
	Lettuce	Montgomery	Md.	Spring 1960	<5	8.0
	Onions	El Dorado	Calif.	Sept. 15, 1960	ND	
	Onions	Newaygo	Mich.	Aug. 25, 1960-Sept. 20, 1960	ND	
	Onions	Brooks	Oreg.	Sept. 15, 1960	ND	
	Potatoes	Johnson	Kans.	July 4, 1960	0.7	
	Potatoes	Stockton	Calif.	Aug. 17, 1960.	ND	0.4
	Sweet potatoes	Ashville	N. C.[1]	Jan. 10, 1960[1]	49	
	Spinach (canned)	Muskegon	Mich.	June 20, 1960	ND	
Fruits	Apples	Okanogan	Wash.	Oct. 1960	ND	
	Apples	Lockport	N. Y.[1]	Oct. 30, 1960	4.0	
	Applesauce (strained)	Kent, Mason & Ocean	Mich.	Oct. 15, 1959	9.1	
	Apricots (dried)	San Jose	Calif.[1]	July 14, 1960	<10	4.9
	Bananas (strained)		Mex.	Jan. 24, 1961	ND	
	Peaches	San Jose	Calif.	Aug. 12, 1960	ND	0.43
	Peaches (strained)	San Jose	Calif.[1]	1960	ND	0.17
	Peaches	Carroll	Md.	Sept. 20, 1960	108	
	Peach peelings	Franksburg	Md.	Aug. 23, 1960	67	6.6
	Peaches	Cross Junction	Md.	Aug. 24, 1960	ND	1.5
	Peaches	Fremont	Mich.	Aug. 25, 1960	<2	1.2
	Tomatoes	Hancock	Va.	Sept. 1, 1960	11	2.6
	Tomatoes	Salem	Va.	Aug. 31, 1960	20	1.5
	Tomatoes	Greenville	Ohio[1]	1960[1]	ND	1.2
	Tomatoes (canned)	Madison	Ark.[1]	Jan. 9, 1961[1]	13	
Nuts	Cashews		S. India	1960	ND	
	Walnuts	Lake	Calif.	Oct. 1, 1961	17	
	Pecans	Orangeburg	S. C.	Fall 1960	ND	
	Walnuts	Marion	Oreg.[1]	Fall 1960	ND	
	Pecans	Lincoln	Okla.[1]	Apr. 6, 1961[1]	ND	
Dairy products	Milk (powdered)	Gingham, Bonneville, Jefferson	Idaho	1961	1.6	24
	Milk (evaporated)	Albany	Oreg.[1]	Dec. 20, 1960[1]	ND	12
	Milk	Mt. Vernon	Mo.[1]	Dec. 26, 1960[1]	25	
	Milk (evaporated)	Weld	Colo.	Dec. 16, 1960[1]	ND	
	Milk (evaporated)	Twin Falls	Idaho	Dec. 30, 1960[1]	ND	
	Cheese	Bongards	Minn.[1]	Sept. 15, 1960[1]	ND	
	Cheese	E. Aurora	N. Y.[1]	Dec. 28, 1960[1]	ND	
	Cheese	Pocatello	Idaho[1]	Jan. 4, 1961[1]	120	
	Cheese (cheddar)	Mt. Angel	Oreg.[1]	Jan. 3, 1960[1]	ND	104
	Cheese (cheddar)	Pike	Mo.	Jan. 23, 1961[1]	ND	
	Cheese (cheddar)	Bongards	Minn.[1]	Oct. 15, 1960[1]	26	27
	Eggs (liquid)	Wright	Minn.	Feb. 27, 1961	6.8	
	Eggs (shell)	Wright	Minn.	Feb. 27, 1961	21	
Grain & grain products.	Oat flour	Cedar Rapids	Iowa	1959[1]	70	11
	Oat flour	Cedar Rapids	Iowa	1959[1]	70	2.6
	Corn flour	Milwaukee	Wis.	1960[1]	5.2	0.09
	Oat flour	Cedar Rapids	Iowa[1]	Sept. 8, 1960[1]	23	
	Flour	Penn Yan	N. Y.[1]	Dec. 27, 1960[1]	ND	
	Corn Meal	Crawford	Ill.	Oct. 18, 1960[1]	5.9	0.17
	Flour	Montezuma	Colo.	Sept. 12, 1960[1]	1.4	
	Wheat	Gardner	Kans.[1]	1960[1]	82	20
	Wheat	Montgomery	Ill.	1960	105	19
	Wheat	Roseville	Calif.	1960	16	7.5
	Wheat	Taylor	Tex.		<25	7.0
	Wheat	Summerville	Mo.[1]	Jan. 11, 1961[1]	50	50
	Wheat	Big Horn, Campbell & Sheridan	Mont. Wyo.	Dec. 8, 1960	ND	
	Rice	Woodruff & Cross.	Ark.	Jan. 12, 1961[1]	52	
	Rice	Lonoke	Ark.	Oct. 1, 1960	ND	
	Wheat[3]	Walworth & Edmunds	S. D.	Aug. 1960	60	7.6
	Bran[3]	Walworth & Edmunds	S. D.	Aug. 1960	128	23
	Flour[3]	Walworth & Edmunds	S. D.	Aug. 1960	53	4.9
Baby foods	Beets (jr. food)	St. Paul	Minn.[1]	Apr. 13, 1960[1]	125	1.4
	Green beans (strained)	Transylvania & Henderson	N. C.	July 21, 1960	40	22
	Green beans (strained)	Mecosta & Newaygo	Mich.	Aug. 24, 1960[1]	5.3	15
	Green beans (strained)	Genesee & Livingston	N. Y.	Aug. 22, 1960	8.7	8.6
	Peas (strained)	Orleans & Genesee	N. Y.	July 18, 1960	3.6	2.4
	Spinach (strained)	Orleans & Genesee.	N. Y.	June 7, 1960	16	7.5
	Squash (strained)	Newaygo & Muskegon	Mich.	Sept. 7, 1960	2.6	4.4
	Veal (jr. food)	St. Paul	Minn.	July 19, 1960	65	0.8
	Pork (strained)	St. Paul	Minn.[1]	May 24, 1960	33	0.13
	Lamb & Broth (strained)	St. Paul	Minn.[1]	June 10, 1960	22	0.46

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TABLE 1.—RADIOANALYSES OF RAW AND PROCESSED FOODS—Continued

[Concentrations in μμc/kg original material]

Category	Product	Origin		Date harvested or processed	Cesium-137	Strontium-90
		County or city	State or country			
Seafood	Sardines	San Francisco	Calif.	July 14, 1960	ND	1.2
	Tuna Fish		Japan	1960	38	0.3

[1] City processing location; all other locations are counties where produce originated.
[2] ND—Not detectable.
[3] Processed from same wheat crop.

TABLE 2.—RADIOANALYSIS FOR STRONTIUM-90 IN TEAS HARVESTED IN 1958 AND 1959

[Concentration in μμc/kg original material]

Form	Country	Number of samples	Strontium-90	
			Average	Range
Leaf	India	9	632	235–1,094
	Japan	13	591	227–1,662
	Formosa	5	353	236– 448
	Indonesia	7	125	63– 419
	Ceylon	8	186	66– 354
	Pakistan	2	719	707– 731
	Tanganyika	1	48	
	Kenya	2	188	146– 230
	Belgian Congo	3	70	54– 94
	Mauritius	1	175	
	Brazil	2	184	174– 193
Soluble	Manufacturer A		14	
	Manufacturer A		32	
	Manufacturer B		30	

TABLE 3.—STRONTIUM-90 CONTENT OF VARIOUS FOODS HARVESTED IN 1960

[Concentrations in μμc/kg original material]

Category	Product[1]	Area		Harvest month	Strontium-90
		County	State or country		
Wheat & Derivatives	Wheat (a)	Texas	Mo.	July	50
	Flour (a)	Texas	Mo.	July	7.6
	Wheat (b)	Greenbrier	W. Va.	October	58
	Bran (b)	Greenbrier	W. Va.	October	74
	Flour (b)	Greenbrier	W. Va.	October	5.5
	Wheat (c)	Cache	Utah	August	3.4
	Bran (c)	Cache	Utah	August	53
	Wheat (d)	Camas	Idaho	September	5.7
	Bran (d)	Camas	Idaho	September	7.7
	Wheat bran (e)	Walworth	S. D.	August	23
	Flour (e)	Walworth	S. D.	August	4.9
	Wheat	Monroe	Mich.	July	19
	Wheat	Johnson	Kans.	June	19
	Wheat	Johnson	Kans.	July	29
	Wheat	Wayne	N. Y.	1960[2]	18
	Wheat	Walla Walla	Wash.	July	3.6
	Bran	Randolph	Mo.	July	54
	Bran	Kimball	Nebr.	July	49
Vegetables	Celery	Orange	N. Y.	September	3.3
	Celery	Wayne	N. Y.	September	9.3
	Celery	Monterey	Calif.	September	0.76
	Celery	Ventura	Calif.	September	1.5
	Celery	King	Wash.	November	2.0
	Celery	Hamilton	Ohio	October	4.2
	Onions	Madison	N. Y.	September	0.65
	Onions	Genesee	N. Y.	September	0.27
	Onions	Racine	Wis.	September	2.7
	Green beans, fresh (f)	Cattaraugus	N. Y.	September	5.0
	Green beans, canned (f)	Cattaraugus	N. Y.	September	0.42
	Green beans, fresh	Erie	N. Y.	September	3.4
	Green beans, fresh	Dorchester	Md.	September	14
	Green beans, canned	Oconto	Wis.	August	10
	Green beans, canned	Manitowoc	Wis.	August	6.0
	Snap beans, fresh	Hidalgo	Tex.	November	3.5
	Carrots, canned	Wayne	N. Y.	September	1.1
	Carrots, raw	Spokane	Wash.	November	3.3
	Carrots, raw (g)	Yakima	Wash.	November	2.0
	Carrots, canned (g)	Yakima	Wash.	November	1.0
	Carrots, frozen	Walla Walla	Wash.	November	1.7
	Carrots, raw	Clackamas	Oreg.	November	2.4
	Carrots, raw (h)	McHenry	Ill.	November	7.1
	Carrots, canned (h)	McHenry	Ill.	November	3.2
	Carrots, canned	Marquette	Wis.	October	6.3
	Carrots, raw	Washington	Wis.	October	4.1
	Carrots, raw	Manitowoc	Wis.	November	4.3
	Spinach, fresh	Yates	N. Y.	October	6.3
	Spinach, frozen	Yates	N. Y.	October	4.0
	Spinach, fresh	San Diego	Calif.	March	9.2

TABLE 3.—STRONTIUM-90 CONTENT OF VARIOUS FOODS HARVESTED IN 1960—Continued

[Concentrations in $\mu\mu c$/kg original material]

Category	Product[1]	Area		Harvest month	Strontium-90
		County	State or country		
	Spinach, frozen	San Diego	Calif.	March	3.5
	Cabbage	Johnson	Kans.	1960[2]	7.1
	Cabbage	Hennepin	Minn.	July	4.4
	Cabbage	Monterey	Calif.	August	1.1
Fruits[3]	Peaches, fresh (i)	Niagara	N. Y.	September	0.45
	Peaches, canned (i)	Niagara	N. Y.	September	0.74
	Peaches, canned (i)	Monroe	N. Y.	September	3.6
	Peaches, fresh	Frederick	Va.	August	1.5
	Peaches, fresh	Van Buren	Mich.	September	1.2
	Peaches, fresh	Mason	Mich.	September	1.4
	Peaches, canned	Berrien	Mich.	September	3.1
	Peaches, canned	Oceana	Mich.	September	8.9
	Peaches, fresh	Valencia	N. Mex.	September	0.45
	Peaches, fresh	Box Elder	Utah	September	0.52
	Peach peels	Carroll	Md.	August	6.6
	Tomatoes, canned	Erie	N. Y.	September	0.82
	Tomatoes, canned	Wayne	N. Y.	September	0.21
	Tomatoes, canned	Weber	Utah	September	0.53
	Tomatoes, fresh (j)	Box Elder	Utah	September	0.57
	Tomatoes, canned (j)	Box Elder	Utah	September	0.58
	Tomatoes, fresh (k)	Weld	Colo.	September	1.9
	Tomatoes, canned (k)	Weld	Colo.	September	0.80
	Tomatoes, fresh	Adair	Okla.	August	1.9
	Tomatoes, canned (l)	Adair	Okla.	August	1.2
	Tomatoes, fresh (l)	Adair	Okla.	August	5.3
	Tomatoes, fresh	Darke	Ohio	September	1.2
	Apples, whole, fresh	Wayne	N. Y.	October	1.0
	Apples, whole, fresh	Dutchess	N. Y.	September	0.89
	Apples, whole, fresh	Columbia	N. Y.	September	1.1
	Apples, whole, fresh	Ulster	N. Y.	September	1.3
	Apples, whole, fresh	Valencia	N. Mex.	October	1.4
	Apples, pulp (m)	Luzerne	Pa.	October	0.44
	Apples, peel (m)	Luzerne	Pa.	October	0.63
	Apples, core (m)	Luzerne	Pa.	October	1.0
	Apples, peel (n)	Niagara	N. Y.	October	1.3
	Apples, core (n)	Niagara	N. Y.	October	1.6
	Apples, peel (o)	Doniphan	Kans.	September	1.8
	Apples, core (o)	Doniphan	Kans.	September	2.1
Dried fruits	Raisins	Fresno	Calif.	September	3.9
	Raisins	Madera	Calif.	September	2.0
	Raisins	Tulare	Calif.	May	2.5
	Figs		Greece	1960[2]	7.7
	Figs		Greece	September	6.8
	Figs		Greece	1960[2]	9.3
	Figs		Turkey	October	2.1
	Fig paste		Turkey	November	7.8
	Fig paste		Turkey	November	7.7
	Fig paste		Portugal	October	9.4
	Dates		Portugal	1960[2]	8.7
	Dates		Iraq	1960[2]	0.59
	Dates		Iraq	1960[2]	1.5
Seafoods	Sardines		Calif.	October	0.54
	Sardines		Calif.	Calif.	1.2
	Sardines		Calif.	1960	0
	Sardines		Calif.	1960	0
	Haddock		Atlantic Coast	1960	0.33
	Haddock		Atlantic Coast	October	0.10
	Haddock		Atlantic Coast	February	2.1
	Oysters		Chesapeake Bay	November	0.43
	Clams		Chesapeake Bay	November	4.6
Dairy products	Milk, evaporated	Linn	Oreg.	December	12
	Milk, evaporated		Wis.	November	12
	Cheese, cheddar		Minn.	January	51
	Cheese, cheddar		Minn.	1960	27
	Cheese, cheddar		Oreg.	1960	104
Baby food	Applesauce			1960	1.1
	Applesauce			1960	1.2
	Peaches			1960	0.13
	Peaches			1960	0.43
	Bananas			1960	0.19
	Green beans			1960	22
	Green beans			1960	15
	Green beans			1960	8.6
	Spinach			1960	7.5
	Squash			1960	4.4
	Peas			1960	2.8
	Beets			1960	4.8
	Lamb			1960	0.35
	Lamb & lamb broth			1960	0.46
	Pork			1960	0.13
	Beef & beef broth			1960	0.89
	Oat flour			1960	2.6
	Corn flour			1960	0.10

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[1] Code letters in parentheses indicate same lots of crop, i.e., flour (a) derived from Texas, Mo. wheat (a).
[2] Month not available.
[3] Where designated fresh, fruit is unpeeled.

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Tri-City Diet Study

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

The dietary survey of strontium-90 content of average diets of individuals living in New York City, San Francisco and Chicago was continued by the Health and Safety Laboratory. The results of the fourth sampling are presented in table 1. Previous data were reported in HASL-90 (*1*), 111 (*2*), and 113 (*3*) and presented in *Radiological Health Data*, Volume II, Numbers 4, 6 and 10.

Selected foods, representing 19 food categories, are purchased at each of these three cities about every three months and are analyzed for strontium-90 and stable calcium. Using data from the U.S. Department of Agriculture, "Household Food Survey of 1955," the annual consumption by an individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 and calcium can then be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general. Hence, in the tables that follow, the values shown for food consumption may not be directly related to the original data in the source document.

The data indicate that there has been no substantial change in the relative contributions of the various foods to the total intake, or in the total intake of strontium-90 since the last sampling. Contributions of this element from tap water are not included in table 1. However, recent measurements show the contributions from tap water to have 132, 176, and 132 μμc of strontium-90 per year at New York City, Chicago and San Francisco, respectively. It was assumed in making these estimates that the average daily intake of tap water is 1.2 liters.

Using the totals given in table 1, the following average concentrations in μμc Sr^{90}/gm Ca may be derived for the year: New York, 9.3; Chicago, 9.1; San Francisco, 3.9.

No seasonal effect on the strontium-90 levels in food can yet be observed. Due to the resumption of atmospheric testing of nuclear weapons, it will be difficult to determine how the levels might have varied with season had the moratorium been continued.

REFERENCES

(*1*) *Quarterly Summary Report, HASL-90,* August 18, 1960

(*2*) *Quarterly Summary Report, HASL 111,* April 1, 1961

(*3*) *Data from Quarterly Summary Report, HASL-113,* July 1, 1961

TABLE 1.—STRONTIUM-90 LEVELS OF DIET—FOURTH SAMPLING

Food type	Annual consumption (kg/yr)	New York City February 1961		Chicago April 1961		San Francisco April 1961	
		μμc/kg	μμc/yr	μμc/kg	μμc/yr	μμc/kg	μμc/yr
Whole grain products	11	6.4	70	16.6	183	12.5	138
Refined grain products	37	8.7	322	9.7	358	6.5	242
Refined grain flour	43	5.8	251	8.2	351	0.5	23
Milk, liquid	221	7.9	1,735	5.3	1,164	2.1	464
Potatoes	45	4.6	207	4.2	189	2.8	126
Macaroni	3	3.6	11	4.0	12	3.5	10
Beans, dried	3	19.4	58	20.4	61	1.3	4
Vegetables, canned	20	2.5	50	6.6	132	0.9	16
Vegetables, fresh	43	3.5	151	9.5	416	2.4	103
Vegetables, root	17	4.4	75	9.5	155	3.6	61
Fruit, canned	26	2.2	58	1.1	29	9.4	25
Fruit juices	19	2.3	43	3.5	66	2.0	38
Fruit, fresh	68	6.5	442	4.1	279	2.3	157
Rice	3	0.1	0	1.9	6	1.7	5
Eggs	16	1.3	21	1.7	26	2.0	20
Fish, fresh	8	0.7	5	0.4	28	0.1	1
Fish, shell	1	0.9	1	0.5	1	3.9	4
Meat	73	0.7	47	0.3	23	0.3	21
Poultry	17	0.3	6	0.6	11	0.6	11
Total annual intake			3,553		3,493		1,482

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SECTION III.—MILK

Milk Monitoring Program

Division of Radiological Health, Public Health Service

There have been two Public Health Service Milk Monitoring Programs since the first quarter of 1960. The original network was established to develop sampling and radiochemical analytical proficiencies under conditions which would remain similar over a period of time in regard to the source of milk. During the operation of this program it became apparent that a broader sampling program more directly related to the milk consumed by the population was necessary. The result was a transition from the program of sampling raw milk, collected from milksheds of limited size, to a sampling program designed to be representative of the processed milk consumed in a given municipality. The establishment of the processed milk area sampling stations did not preclude the need for further raw milk sampling from the selected milkshed serving the same city. It was important that both networks be in operation for a sufficient period of time to provide an overlap for the purpose of a comparative study.

The processed milk area sampling stations provide adequate information as to the radionuclide content of milk. There has now been a sufficient period of overlap in the two sampling programs. Therefore, the reporting of the results of the raw milk sampling stations in *Radiological Health Data* was terminated with the publication of the June 1961 results in Volume II, Number 11.

Publication of the data from the program will normally follow about four months after sample collection because of the time required for shipment, processing, decay-product buildup, compilation of the data, and clearance and publication procedures.

Processed Milk Area Sampling Stations

During 1960, a processed milk surveillance program of about 60 stations was established to provide information on levels of radioactivity in fluid milk consumed by the public. These stations were established in cooperation with State and local health and milk sanitation agencies. Each city was selected to provide adequate coverage with respect to production areas and the consuming population. The emphases of this expanded sampling and radioassay program are:

1. to measure the levels of radioactivity of the milk consumed by the public in various regions of the country by obtaining samples of pasteurized and homogenized milk at the processing plant, and
2. to provide one sampling point within each State with additional points when indicated by widely varying conditions of the milk supply or the need to provide coverage of large population groups.

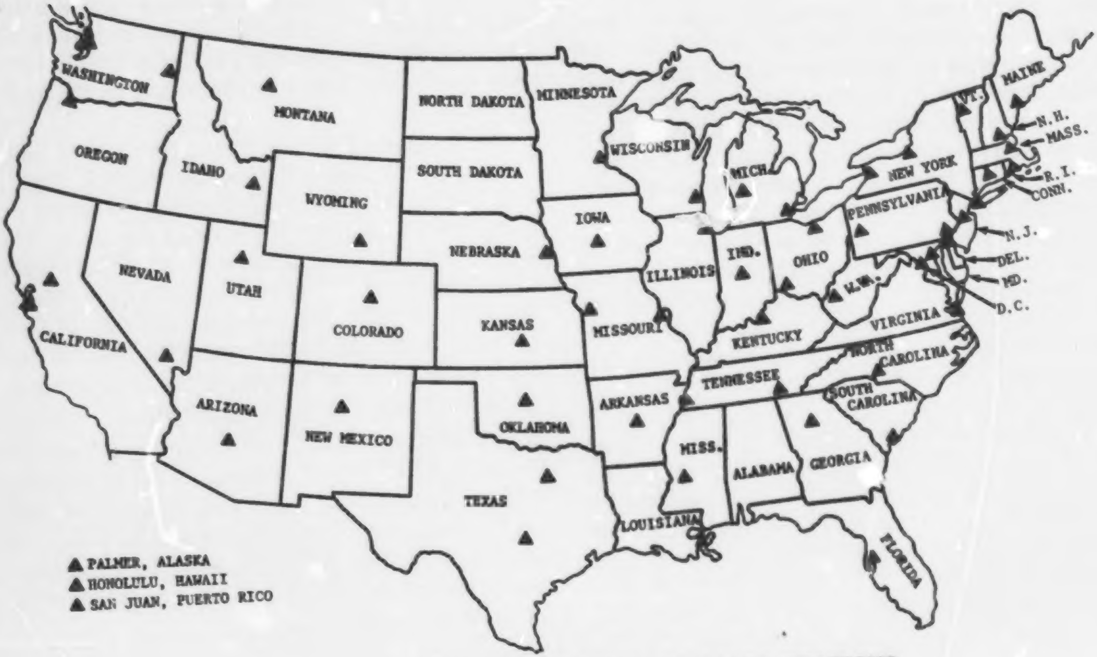
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
WISCONSIN
MICH.
NEW YORK
VT.
MAINE
N.H.
MASS.
R.I.
CONN.
WYOMING
IOWA
PENNSYLVANIA
N.J.
DEL.
MD.
D.C.
NEVADA
UTAH
NEBRASKA
ILLINOIS
IND.
OHIO
W.VA.
COLORADO
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
CALIFORNIA
NORTH CAROLINA
TENNESSEE
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
SOUTH CAROLINA
MISS.
ALABAMA
GEORGIA
TEXAS
LOUISIANA
FLORIDA
PALMER, ALASKA
HONOLULU, HAWAII
SAN JUAN, PUERTO RICO

FIGURE 1.—PROCESSED MILK AREA SAMPLING STATIONS

TABLE 1.—RADIOACTIVITY IN MILK—PROCESSED MILK AREA SAMPLING STATIONS, SECOND QUARTER AND JULY 1961

[Radioactivity concentrations in μμc/liter]

Area	Calcium (gm/liter)		Strontium-90		Cesium-137	
	Second quarter	July	Second quarter	July	Second quarter	July
Albuquerque, N.M.	1.06	1.08	5	2	5	<5
Atlanta, Ga	1.29	1.20	10	10	20	20
Austin, Tex	1.24	1.18	3	2	5	<5
Baltimore, Md	1.23	1.14	8	12	15	25
Boston, Mass	1.21	1.17	11	12	35	40
Buffalo, N. Y	1.22	1.13	8	8	15	15
Burlington, Vt	1.22	1.19	8	10	15	20
Charleston, S. C	1.25	1.19	12	10	25	25
Charleston, W. Va	1.20	1.19	9	10	15	10
Charlotte, N. C	1.26	1.20	12	12	15	15
Chattanooga, Tenn	1.33	1.24	11	11	15	15
Chicago, Ill	1.17	1.12	8	6	10	20
Cincinnati, Ohio	1.24	1.19	9	10	10	<5
Cleveland, Ohio	1.20	1.24	8	6	10	5
Dallas, Tex	1.24	1.18	9	8	10	20
Denver, Colo	1.01	1.04	6	5	5	10
Des Moines, Iowa	1.01	1.10	7	7	5	10
Detroit, Mich	1.17	1.15	8	7	15	<5
Grand Rapids, Mich	1.25	1.18	7	6	15	10
Hartford, Conn	1.17	1.13	9	10	30	20
Helena, Mont	1.02	1.07	6	7	10	15
Honolulu, Hawaii	0.96	1.00	4	5	10	10
Idaho Falls, Idaho	1.04	1.06	5	9	10	10
Indianapolis, Ind	1.23	1.18	8	6	10	20
Jackson, Miss	1.35	1.26	14	10	15	20
Kansas City, Mo	ᵃ 1.08	1.06	ᵃ 12	11	ᵃ 15	10
Laramie, Wyo	1.00	1.01	5	8	10	10
Las Vegas, Nev	1.00	1.02	3	3	5	5
Little Rock, Ark	1.21	1.22	19	17	25	15
Louisville, Ky	1.18	1.10	11	9	10	<5
Manchester, N. H	1.23	1.20	12	10	45	55
Memphis, Tenn	1.30	1.26	13	10	10	10
Milwaukee, Wis	1.19	1.20	6	5	20	10
Minneapolis, Minn	1.07	1.04	7	10	10	20
New Orleans, La	1.30	1.27	13	12	20	20
New York, N. Y	1.17	1.14	9	10	25	15
Norfolk, Va	1.26	1.20	9	10	20	20
Oklahoma City, Ok	1.22	1.16	8	6	5	<5
Omaha, Nebr	1.07	1.30	6	9	10	10
Palmer, Alaska	1.03	1.05	9	7	5	5
Philadelphia, Pa	1.18	1.18	9	10	15	15
Phoenix, Ariz	0.97	1.01	5	3	5	<5
Pittsburgh, Pa	1.27	1.15	12	14	20	20
Portland, Me	1.26	1.16	10	11	40	40
Portland, Oreg	1.05	1.05	12	12	30	30
Providence, R. I	1.17	1.19	10	12	40	45
Sacramento, Calif	1.05	1.05	5	5	<5	5
Salt Lake City, Utah	1.01	1.18	5	3	10	10
San Francisco, Cal	1.04	1.10	5	4	10	5
San Juan, P. R	1.23	1.16	4	4	5	<5
Seattle, Wash	1.03	1.02	9	14	25	20
Spokane, Wash	1.02	1.05	8	8	15	15
St. Louis, Mo	1.09	1.10	8	7	20	10
Syracuse, N. Y	1.19	1.18	7	7	15	10
Tampa, Fla	1.23	1.19	6	6	110	70
Trenton, N. J	1.17	1.16	9	8	15	15
Washington, D. C	1.18	1.12	8	8	20	15
Wichita, Kans	1.01	1.21	8	14	10	5
Wilmington, Del	1.20	1.18	10	8	15	30
Average	1.16	1.14	8	8	15	15

ᵃ Average based on two Months' samples.

The processed milk sampling program was designed to sample processed fluid milk (pasteurized and homogenized) rather than the raw product. The sampling procedure was originally developed to provide a sample from one day's sales per month in a community which would be as representative of the total supply as can be achieved under practical conditions. Each sample is a composite of those plants supplying not less than 90 percent of a city's milk supply. The contribution from each plant to the total sample is approximately proportional to the volume of milk sold. Due to the resumption of weapons testing, the frequency of sampling was increased during September and October.

The samples from the processed milk stations are collected with the assistance of the various State and local health and milk sanitation agencies and are shipped for analyses to either the Southeastern or Southwestern Radiological Health Laboratory. The Southeastern Radiological Health Laboratory processes samples from the 30 states generally east of the Mississippi, and the Southwestern Radiological Health Laboratory processes samples from the western states. Figure 1 shows the locations of these stations.

Radioassays for Sr^{90}, Cs^{137}, Sr^{89}, Ba^{140}, and I^{131} are performed. The values for Sr^{89}, Ba^{140}, and I^{131} for July 1961 were below the levels of detection by present instrumentation and are therefore not shown in table 1. The lower level of detection for Sr^{89} is 5 μμc/liter, and for Ba^{140} and I^{131}, 10 μμc/liter. Other radionuclides of concern to public health agencies will be included for assay as necessary for a more complete monitoring of the milk supply.

The program of daily sampling for I^{131} analyses was continued at selected stations. Table 2 presents daily laboratory results from October 11-31, 1961, for those stations. *Radiological Health Data,* Volume II, Number 11, presented the daily I^{131} results for the period September 19 through October 10, 1961.

TABLE 2.—DAILY IODINE-131 DETERMINATIONS, PROCESSED MILK AREA SAMPLING STATIONS, OCTOBER 11-31, 1961

[Concentrations in μμc/liter]

Area	October																				
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Atlanta, Ga.	70	70	100	—	—	70	120	50	50	60	—	—	10	40	40	70	70	—	—	20	30
Austin, Tex.	30	20	40	20	20	20	20	20	30	30	20	—	20	20	60	20	30	50	50	30	50
Charleston, S. C.	50	70	50	60	—	50	20	50	30	50	50	—	40	50	40	70	30	20	—	50	—
Chicago, Ill.	150	150	160	—	—	120	110	120	110	120	—	—	100	120	130	110	110	—	—	150	130
Denver, Colo.	100	—	—	80	—	110	100	—	90	90	80	—	—	—	—	60	—	—	—	—	50
Jackson, Miss.	100	110	90	—	—	80	60	50	50	60	—	—	70	50	50	50	50	—	—	20	—
Milwaukee, Wis.	140	140	120	140	180	130	130	110	140	130	90	100	50	120	130	180	180	160	210	170	150
New Orleans, La.	90	80	60	—	—	80	50	70	50	60	—	—	50	40	80	60	60	—	—	50	20
New York, N. Y.	110	—	100	70	—	70	80	80	130	90	100	—	100	100	120	90	90	70	—	80	90
Omaha, Nebr.	240	300	—	90	—	320	260	250	—	—	—	—	120	150	150	170	—	—	—	140	90
Palmer, Alaska	—	—	—	—	—	—	—	—	—	—	—	—	270	220	—	150	—	—	120	—	90
Pascagoula, Miss.	80	110	120	—	—	80	90	80	70	70	—	—	70	40	30	70	70	—	—	20	40
Sacramento, Calif.	<10	<10	<10	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	90	90
Salt Lake City, Utah	120	130	120	—	—	100	100	120	90	100	—	—	100	100	120	100	130	—	—	110	160
Seattle, Wash.	80	90	110	110	—	110	120	90	110	90	110	—	90	100	80	100	150	260	200	—	350
St. Louis, Mo.	150	170	150	140	—	150	120	120	110	110	150	—	140	120	110	120	120	140	—	100	80
Tampa, Fla.	—	—	—	—	—	—	—	30	20	50	—	—	40	30	50	70	50	—	—	40	—
Washington, D. C.	80	70	—	70	—	50	40	50	60	50	40	—	50	60	80	80	70	80	—	60	—
Wichita, Kans.	—	120	120	100	—	—	100	110	—	140	140	150	—	120	120	—	120	130	—	100	—

Raw Milk Sampling Stations

The June 1961 data presented in *Radiological Health Data,* Volume II, Number 11, are the last regular publication of the results from the raw milk sampling program. The limitations inherent in the size of the program and the procedures used for collecting milk samples have made necessary the broader program more directly related to the milk consumed by the population. The establishment of the Processed Milk Area Sampling Stations resulted from this need, and, after a period of overlap, obviated the necessity for continued publication of the raw milk data. Collection and analyses of samples of raw milk will continue in connection with research on factors influencing the levels of radionuclides in milk and the results will be made available from time to time.

The following discussion by personnel of Milk and Food Research, and Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Public Health

Service, summarizes the results of the Raw Milk Sampling Program.

SUMMARY RESULTS FROM RAW MILK SAMPLING PROGRAM

The Public Health Service undertook early in 1957 an investigation to determine the amounts and kinds of fission products in foods in response to increasing awareness that the nuclear weapons tests of various nations were resulting in the discharge of ever-increasing amounts of radioactive contaminants into the environment and in recognition of the damaging capabilities of "high" concentrations of at least some of these products.

Milk was chosen as the first item of the diet to be surveyed. Reasons for this choice includes: (a) evidence indicates that milk was probably a major contributor of Sr^{90} to the total diet, (b) milk is consumed extensively by almost all segments of the population, especially children, (c) milk is produced on a year-round basis in almost every area of the United States and, (d) this food item offers the possibility of developing one set of methods that would be equally applicable to all samples.

Preliminary examination of several market milk supplies using methods of analysis available at the time showed that cesium-137, iodine-131, strontium-89, strontium-90, and barium-140 were present in significant concentrations and led to the decision that all of them should be routinely determined. With this in mind, a sequential system of analysis for these fission products was developed (*3,5,6*). Attention was given particularly to the development of simple and relatively fool-proof methods which could be successfully carried out by well trained but non-professional personnel and which were suitable for use with large numbers of samples. A technique was developed by which milk could be transported from distant locations to a central laboratory for analysis by the addition of 4 ml of 40% formaldehyde per gallon of milk and using air parcel post for transportation. Samples handled in this manner almost without exception will remain in a fluid state without obvious decomposition and will be satisfactory for radionuclide analysis for over one week.

Monthly collections of raw milk samples were taken from discrete geographical areas within specified milksheds serving large urban populations in different regions of the United States. The following criteria were used in developing each of these stations:

1. The milk represented in each sample was from a group of farms milking a total of at least 1,000 cows.
2. The number of individual farms was small enough so that collection of collateral field data from each farm was feasible.
3. The milk samples were from a supply that was part of a metropolitan milkshed.
4. The conditions under which the milk was received were such that each sample was representative of the same farms in the production area.

Analysis of samples collected in this manner provided the information necessary for research on the factors influencing the levels of radionuclides in milk as well as some notion regarding radionuclide exposure of population groups in the various metropolitan areas.

During the first year of operation five areas were selected for surveillance: New York, Cincinnati, St. Louis, Salt Lake City, and Sacramento. In the second year stations were added at Atlanta, Chicago, Fargo-Moorhead, Austin, and Spokane. Continuous monthly samples have been received from all stations since their initiation except for Fargo-Moorhead which discontinued participation in January 1960.

Methods

One-gallon raw milk samples are taken monthly from collecting stations in each area under surveillance, preserved with 4 ml of 40% formaldehyde, and forwarded to the Robert A. Taft Sanitary Engineering Center for radionuclide analysis. Each sample collected in a manner to meet the specification previously outlined is representative of lots of milk ranging from 2,000 to 90,000 gallons of the total milk supply of the designated area. The concentrations of iodine-131, barium-140, and cesium-137 are measured by gamma scintillation spectroscopy (*4*) while total radioactive strontium and strontium-90 are determined following radiochemical separation (*6,7*). The amount of strontium-90 is determined by counting, in a low-background anti-coincidence counter, the build-up of yttrium-90 after a two-week ingrowth period. The total radioactive strontium is determined in a shielded proportional counter and the difference between this figure and that determined for strontium-90 is reported as strontium-89. Stable calcium and potassium are also determined routinely on all samples (*9,10*).

Since initiation of the project, several of the analytical procedures have been improved or simplified. Prior to use for surveillance activities each new procedure has been shown to have a precision and sensitivity equal to or better than the method replaced, thus making all of the data obtained in connection with the Raw Milk Sampling Stations comparable with one exception. The initial radiochemical procedure for cesium-137 was found to include a contribution from the beta-emitting rubidium-87 which is not seen by the gamma-spectrometer. Accordingly, the cesium-137 values from May 1957 to January 1959 may be high by as much as 15-20 μμc per liter of milk.

Results and Discussion

Results of analysis for all the samples collected in the Raw Milk Sampling Program from May 1957 through June 1961 have been published elsewhere (*1,2,11*) and accordingly are not tabulated in connection with this summary. Considerations of these results have been limited to the gross relationship between fallout and the occurrence of some of these fission products in milk as influenced by time and geographical location. For purposes of convenience the results have been divided into two groups based upon the half-lives of the radionuclides. The first group consists of strontium-90 and cesium-137, both with half-lives of about 28 years, while the second group consists of iodine-131, barium-140, strontium-89, having half-lives of approximately 8, 13, and 63 days respectively.

Table 3 summarizes the average yearly concentrations of Sr^{90} in the monthly milk samples from each of the locations of the Raw Milk Sampling Program. Based on an analysis of variance of the data obtained during 1959, the cities have been grouped to indicate significant differences between geographical locations. It is seen that there is no significant difference in the average strontium-90 concentration in the milk from Sacramento, Austin, and Salt Lake City. The levels of strontium-90 in the milk from Chicago and New York is higher than the first group of cities, but significantly lower than the concentrations observed in the samples from Cincinnati, Spokane, Atlanta, and Fargo-Moorhead. However, the average concentration of strontium-90 in milk from the portions of the milksheds serving St. Louis is significantly higher than that from any other area. This type of statistical treatment is dependent on the observed variation in the sample and does not infer biologically significant differences.

It is evident also from these data that the relative levels of strontium-90 in milk have remained constant with respect to geographical location throughout the entire study.

Levels of strontium-90 within a given milkshed, however, are not constant. Analysis of the variance, applied to these data, oftentimes revealed significant differences which appeared to be associated with the seasons of the year

TABLE 3.—AVERAGE CONCENTRATION OF STRONTIUM-90 AND CESIUM-137 IN MONTHLY RAW MILK SAMPLES

[Concentrations in μμc/liter]

Station	Strontium-90					Cesium-137				
	1957	1958	1959	1960	[b] 1961	1957	1958	1959	1960	[b] 1961
Sacramento, Calif.	[a] 4.4	5.1	5.0	3.3	3.7	[a] 46	34	23	9	8
Austin, Tex.	-------	[a] 3.5	6.0	4.3	3.5	-------	[a] 23	33	15	8
Salt Lake City, Utah	[a] 4.7	4.3	6.7	6.0	3.5	[a] 57	39	37	30	11
Chicago, Ill.	-------	[a] 7.6	8.6	9.4	6.5	-------	[a] 40	47	30	20
New York, N. Y.	[a] 5.8	6.5	9.3	9.4	8.0	[a] 43	41	39	26	18
Cincinnati, Ohio	[a] 5.9	8.5	12.8	9.9	9.0	[a] 39	48	37	23	16
Spokane, Wash.	-------	[a] 8.8	12.2	11.2	7.5	-------	[a] 50	67	36	17
Atlanta, Ga.	-------	[a] 11.3	15.5	14.6	12.7	-------	[a] 44	66	35	25
Fargo-Moorhead, N. D.	-------	[a] 13.6	14.4	-------	-------	-------	[a] 65	52	-------	-------
St. Louis, Mo.	[a] 9.4	13.2	22.2	18.0	17.3	[a] 50	57	74	29	25

[a] Approximately last half of year.
[b] Through June 1961.

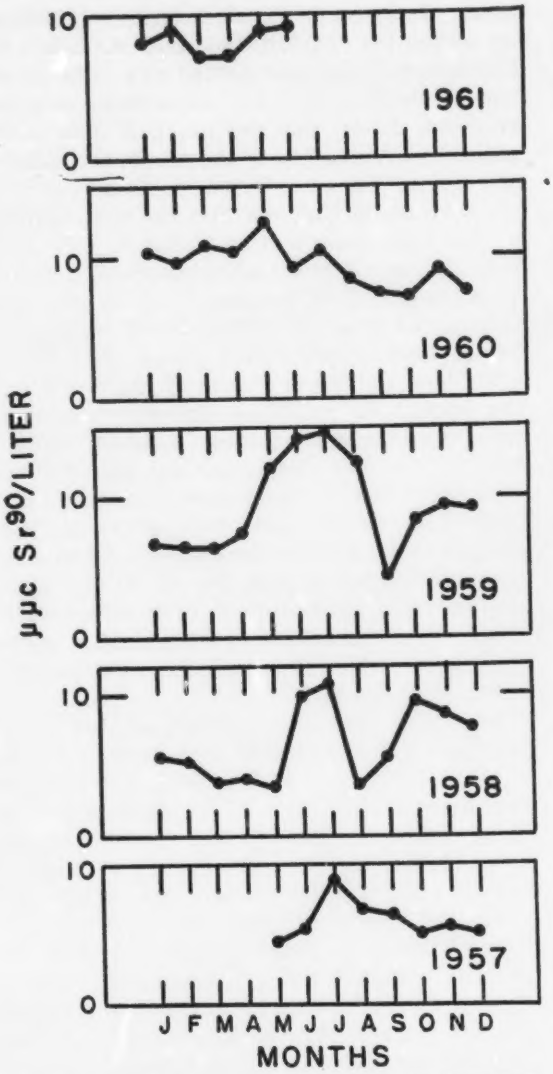

FIGURE 2.—CONCENTRATIONS OF STRONTIUM-90 IN MILK (NEW YORK)

and independent of weapons tests. An example is seen in figure 2. Here, the levels of strontium-90 observed in the milk samples obtained from the New York milkshed have been plotted as a function of time-month. It is seen that there is a pronounced increase in concentration of strontium-90 during the spring months (statistically significant during 1959 and 1960) and again during the fall. Similar variations have been observed in most of the other milksheds although in many cases these differences are not significant.

In table 3, the annual average concentrations of cesium-137 in the monthly milk samples are summarized. In a general way the variations observed with this radionuclide are similar to those observed for strontium-90.

An analysis of variance applied to the 1959 findings indicated that the milk from Sacramento contained significantly less cesium-137 than that from any other area while milk from St. Louis had a significantly higher concentration. The remaining geographical areas fell into one of two intermediate groups as indicated. Seasonal variations as seen in figure 3 were observed in all locations and the samples produced during the spring of 1959 contained significantly more cesium-137 than samples produced at other times. Although there is no clear association between the concentrations of this radionuclide and weapons test activities, the concentration of cesium-137 has decreased at a more rapid rate than strontium-90 in all geographical locations since cessation of weapons tests in October 1958. This is also seen in figure 3 in which the levels of strontium-90 and cesium-137 observed in the samples from Atlanta have been plotted with respect to time. The probable reason for this difference in behavior is related to the differential absorption of strontium-90 and cesium-137 through the root systems of plants although the half-lives of these two radionuclides are approximately the same.

In contrast to the findings with the long half-life radionuclides, correlation between weapons tests and the occurrence of the short half-life radionuclides in milk was observed for all

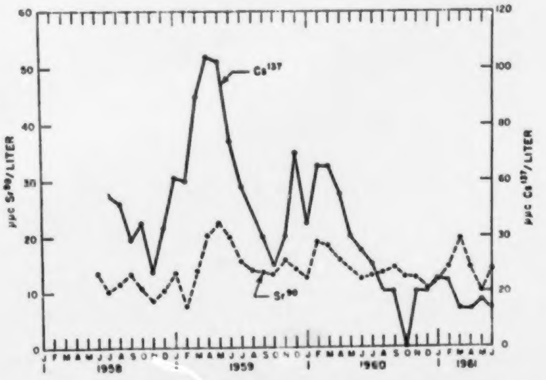

FIGURE 3.—CONCENTRATIONS OF STRONTIUM-90 AND CESIUM-137 IN MILK (ATLANTA)

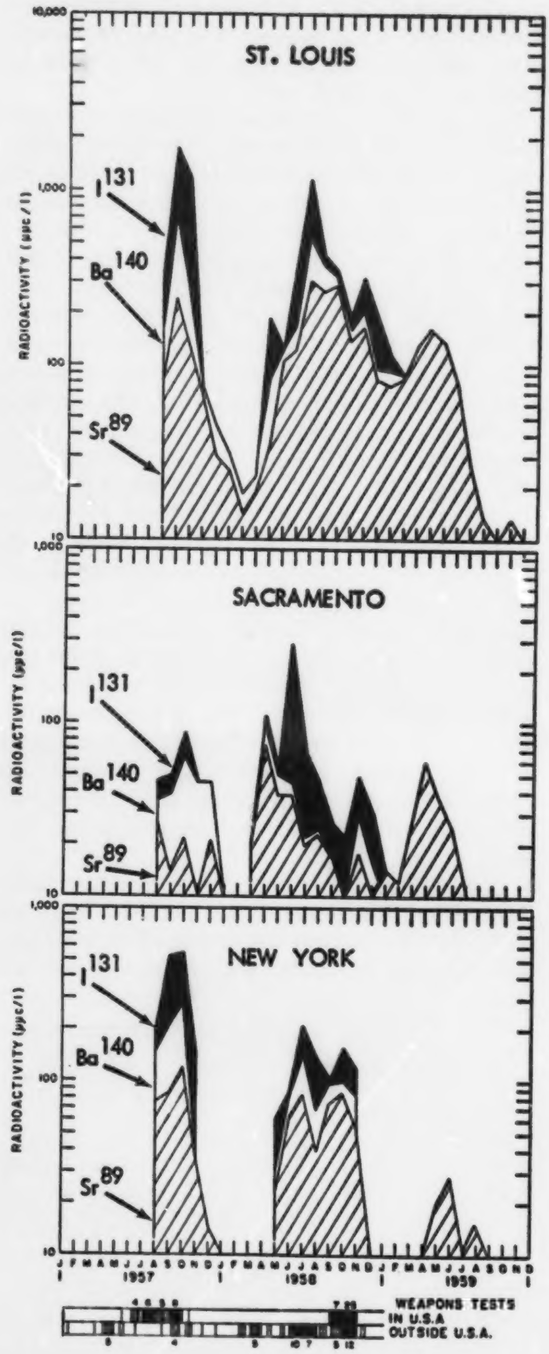

FIGURE 4.—CONCENTRATIONS OF SHORT HALF-LIFE RADIONUCLIDES IN RAW MILK

areas. In figure 4 the radioactivity contributed by iodine-131, barium-140, and strontium-89 has been summed and plotted as a function of time since May 1957 for the samples received from St. Louis, Sacramento, and New York milksheds. At the foot of the graph, the number of weapons tests conducted inside and outside the continental United States has been marked on the same time scale. Although it is clear that the highest levels of radioactivity coincide with the periods of weapons tests, the relationship cannot be established precisely as the number of tests do not reflect fission yield of the explosions and the collection of the samples in the Raw Milk Sampling Stations was made independently of the testing program. This is especially evident during the last period of the continental tests in which most of the explosions were of low fission yield. The pattern of activity observed for New York and St. Louis samples appears to be true for all of the areas studied with the exception of Sacramento in which the concentration of the short-life radionuclides is relatively non-responsive to continental weapons tests.

This difference is presumably related to the location of the milkshed with respect to the Nevada Test Site and the prevailing west to east movement of the air. In all locations, no iodine-131 or barium-140 was observed in any milk samples by the end of 1958 or about 3 months after the last weapons test which coincides well with predictions based on the half-lives of these two radionuclides. The half-life of strontium-89 is sufficiently long that measurable concentrations were expected and observed through the fall of 1959 or about a year after the last test and the seasonal variations previously mentioned were also observed here. Although no weapons tests were conducted in the period under consideration after October 1958, the levels of strontium-89 were found to increase steadily from January 1959 to reach a peak in the spring coinciding with the maximum concentration found in strontium-90 in the same period, thus indicating that additional strontium-89 was deposited during the period or otherwise made available to the cattle. After the spring peak the levels of strontium-89 were found to have decreased at a rate approximately equal to its half-life.

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Radioactivity In Milk

Health and Safety Laboratory, U.S. Atomic Energy Commission

The results of analyses of milk by the Atomic Energy Commission's Health and Safety Laboratory at four locations in the United States for December 1960 and January through April 1961 are presented in table 1. Data for previous months appear in *Radiological Health Data* Volume I, Numbers 1, 2, 3, 5, 7, and 8, and Volume II, Numbers 3 and 6.

TABLE 1.—STRONTIUM-90 AND CALCIUM IN MILK SAMPLES, DECEMBER 1960–APRIL 1961 [1]

Sampling station and month	Strontium-90			Calcium	
	μμc/liter	μμc/kg	μμc/gm Ca	gm/liter	gm/kg
Perry, New York (powdered milk)					
December 1960		49	4.8		10.3
January 1961		65	6.5		10.1
February 1961		65	7.0		9.3
March 1961		59	6.5		9.0
April 1961		65	7.2		9.1
New York City (liquid milk)					
December 1960	7.1		6.3	1.14	
January 1961	7.5		6.7	1.11	
February 1961	7.8		7.3	1.08	
March 1961	9.4		8.1	1.15	
April 1961	8.6		6.5	1.31	
Mandan, North Dakota (powdered buttermilk)					
December 1960		90	10.6		8.5
January 1961		114	10.4		11.0
February 1961		122	11.6		10.5
March 1961		122	10.9		11.2
April 1961		140	12.2		11.5
Honolulu, Hawaii [2] (liquid milk)					
December 1960	3.4 2.4		3.2 3.2	1.07 1.05	
January 1961	2.0 3.0		1.8 2.7	1.12 1.12	
February 1961	2.1 3.6		2.4 3.5	0.88 1.03	
March	1.9 3.2		1.9 3.1	1.01 1.03	
April	1.9 2.8		2.0 2.8	0.96 1.00	

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[1] Data from *Quarterly Summary Reports*, Hasl-113, July 1961 and HASL-115, October 1961.
[2] Two results per month represents milk from two dairies.

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Strontium-90 in Canadian Dried Milk Products

Department of National Health and Welfare,
Dominion of Canada

The following table presents the results of measurements of strontium-90 in Canadian dried milk for the months of January, February, and March, 1961. This table was included in the "Quarterly Report of the Radio-Active Fallout Study Program," dated August 1961, published by the Radiation Protection Division of the Department of National Health and Welfare, Ottawa, Canada. Figure 1 shows the sampling locations. The samples were collected by inspectors of the Marketing Division, Department of Agricuture.

Data for the year of 1960 were published in *Radiological Health Data,* Volume I, Numbers 6 and 9, and Volume II, Numbers 4 and 8.

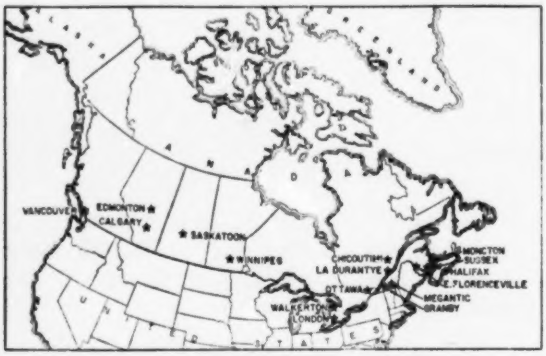
ALASKA
GREENLAND
CANADA
VANCOUVER
EDMONTON
CALGARY
SASKATOON
WINNIPEG
CHICOUTIMI
LA DURANTYE
OTTAWA
WALKERTON
LONDON
MONCTON
SUSSEX
HALIFAX
E. FLORENCEVILLE
MEGANTIC
GRANBY
UNITED STATES

FIGURE 1.—MILK SAMPLING STATIONS IN CANADA

TABLE 1.—STRONTIUM-90 CONTENT OF CANADIAN DRIED MILK POWDER SAMPLES

[Concentrations in μμc/gm calcium]

Station	January 1961	February 1961	March 1961
Calgary	6.9	7.2	6.8
Charlottetown	11.5	10.5	NS [3]
Chicoutimi	10.6	10.2	13.3
E. Florenceville	NS	NS	NS
Edmonton	8.1	8.3	8.8
Granby	6.6	6.2	6.0
Halifax [1]	11.2	8.7	8.7
La Durantye	16.0	11.6	14.9
London	4.3	4.4	4.0
Megantic	12.7	12.9	12.7
Moncton [2]	12.4	10.1	10.0
Ottawa	7.5	6.2	4.1
Saskatoon [2]	8.3	7.1	5.1
Sussex	14.1	8.3	10.7
Vancouver	8.9	9.4	10.1
Walkerton	4.7	6.8	4.8
Winnipeg[2]	5.5	7.1	4.9
Average	9.3	8.4	8.3

[1] New Station. Natural strontium concentration not yet determined. A factor of 1.06 was used for correction of the sample. The results of all other stations were corrected for natural strontium in the sample. This determination was made by neutron activation at A.E.C.L. Chalk River.

[2] Buttermilk sample. All other samples are skim milk.

[3] NS—No milk powder manufactured for the month.

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SECTION IV. — WATER

National Water Quality Network

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network operates under the provision of Section 4 (c) of the Federal Water Pollution Control Act, which states "... The Secretary shall ... collect and sseminate basic data ... (relating) to water pollution and the prevention and control thereof."

This Network, operated in cooperation with State and local agencies, and industrial organizations commenced operations in October 1957. At present, there are 90 sampling stations located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are on interstate, coastal, and International Boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, total of approximately 300 stations will be in operation. Radioactivity is not yet being reported for a few of the more recently established stations.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids in raw rface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of the levels which may be found in a treated water, where such water treatment removes substantially all of the suspended matter. Naturally-occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing for a period of three years, the beta activity in most raw waters generally has approached a level attributable solely to natural sources. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. The resumption of nuclear weapons testing in the atmosphere by the USSR is expected ultimately to raise the level of radioactivity in surface waters again, but no significant increase had been noted to October 1, 1961.

For the first two years of the network operations, beta determinations were made on weekly samples. Alpha determinations were reported generally on composites of more than one weekly sample.

Beginning January 1, 1960, the frequency of beta determinations varied depending on the status of each particular station. For the first operating year of each new station, analyses were being conducted weekly. Weekly analyses were to be continued indefinitely from all stations which may be affected by waste discharges from nuclear installations. Semimonthly determinations on composites of 2 or 3 weekly samples were conducted for stations which still showed some beta activity above background. Monthly determinations on composites of all samples received from a station during the month were conducted on samples from streams where beta activity was at background levels.

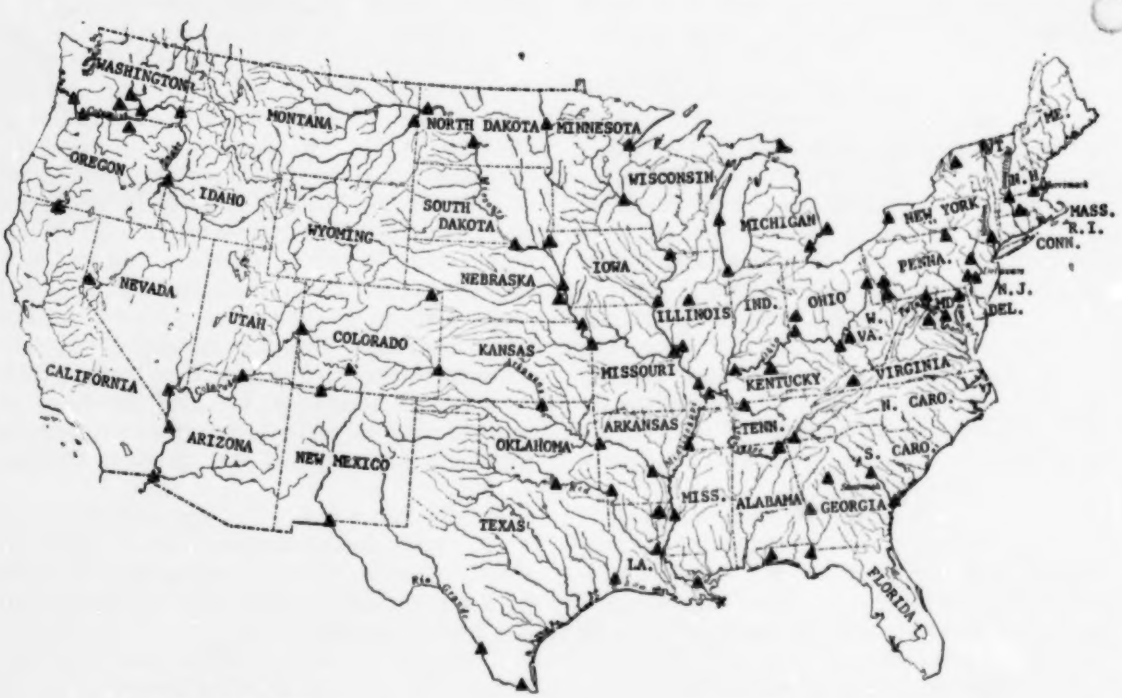
Beginning January 1, 1960, the frequency of alpha determinations also was changed. For the first operating year of each new station, analyses were to be done weekly. Weekly determinations, or semimonthly determinations on composites of 2 or 3 weekly samples, were conducted at some collecting points on the Animas and Colorado Rivers. The remainder of the stations had determinations made quarterly on composites of all samples taken during that quarter. Schedules of determinations were so arranged that each river basin had one gross alpha determination each month.

The following changes were instituted on September 1, 1961, following resumption nuclear weapons testing:

1. Gross beta counts are to be made on all samples collected. (Compositing weekly samples for monthly or semimonthly gross alpha and beta counting will cease.)
2. Beginning with samples collected October 1, 1961, strontium-90 determinations are to be made on a three-month composite of weekly samples.

Gross alpha counts are to be made on one sample for each station each month, unless there is evidence of alpha activity. In the latter instance, an alpha determination will be made on a weekly or bi-weekly basis depending on what is considered the norm for a particular station.

All data reported in table 1 represent the average of all information available for the month indicated. Reported strontium-90 data are the results of determinations on three-month composite samples for a period ending in the month shown. The data were determined on


WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
WISCONSIN
SOUTH DAKOTA
WYOMING
MICHIGAN
NEW YORK
VT.
N.H.
ME.
MASS.
R.I.
CONN.
NEVADA
NEBRASKA
IOWA
PENNA.
N.J.
DEL.
MD.
UTAH
ILLINOIS
IND.
OHIO
W. VA.
COLORADO
KANSAS
CALIFORNIA
MISSOURI
KENTUCKY
VIRGINIA
N. CARO.
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
LA.
FLORIDA

As of August 14, 1961

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Concentrations in μμc/liter]

Station	Quarter ending June 30, 1961	June 1961					
		Beta activity			Alpha activity		
	Strontium-90	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	0.2	0	0	0	0	<1	<1
Animas River: Cedar Hill, N. Mex.	—	2	6	8	<1	4	4
Arkansas River:							
Coolidge, Kansas	—	17	3	20	0	48	46
Ponca City, Okla.	0.7	0	12	12	5	4	9
Big Sioux River: Sioux Falls, S. Dak.	—	0	4	4	1	3	4
Chattahoochie River: Atlanta, Ga.	0.3	<1	<1	1	<1	2	3
Colorado River:							
Loma, Col.	—	7	3	10	3	4	7
Page, Ariz.	2.3	25	<1	26	20	4	24
Boulder City, Nev.	—	0	0	0	0	11	11
Parker Dam, Ariz-Calif.	—	3	1	4	0	8	8
Yuma, Ariz.	—	0	0	0	<1	9	10
Columbia River:							
Wenatchee, Wash.	—	0	0	0	0	0	0
Pasco, Wash.	—	7	41	48	0	0	0
Bonneville Dam, Oreg.	—	24	19	43	0	0	0
Clatskanie, Oreg.	1.1	12	15	27	0	0	0
McNary Dam, Oreg.	—	12	42	54	0	0	0
Connecticut River: Northfield, Mass.	—	0	0	0	0	0	0
Delaware River:							
Martins Creek, Pa.	0.4	0	0	0	0	0	0
Philadelphia, Pa.	—	0	0	0	0	0	0
Escambia River: Century, Fla.	—	0	0	0	1	0	1
Great Lakes:							
Buffalo, N. Y.	—	0	0	0	0	0	0
Detroit, Mich.	—	0	0	0	0	0	0
Port Huron, Mich.	—	0	0	0	0	0	0
Gary, Ind.	—	0	0	0	0	0	0
Milwaukee, Wis.	0.3	0	0	0	<1	<1	<1
Sault Ste. Marie, Mich.	—	0	0	0	0	0	0
Duluth, Minn.	—	0	0	0	0	0	0
Hudson River: Poughkeepsie, N. Y.	0.5	1	2	3	0	0	0
Illinois River: Peoria, Ill.	—	0	12	12	<1	<1	1
Kanawha River: Winfield Dam, W. Va.	—	0	0	0	0	0	6
Klamath River: Copco, Oreg.	0.3	<1	<1	1	0	0	0
Little Miami River: Cincinnati, Ohio	—	0	<1	<1	<1	<1	<1
Merrimac River: Lowell, Mass.	—	0	0	0	0	0	0
Mississippi River:							
Minneapolis, Minn.	—	0	0	0	0	0	0
Dubuque, Iowa	—	0	0	0	0	0	0
Burlington, Iowa	—	0	0	0	1	1	2
E. St. Louis, Ill.	0.5	6	0	6	0	0	0
Cape Girardeau, Mo.	—	0	0	0	8	1	9
West Memphis, Ark.	—	7	1	8	3	1	4
Delta, La.	—	1	2	3	9	2	11
New Orleans, La.	0.6	6	2	8	4	<1	4
Missouri River:							
Williston, N. Dak.	—	19	4	23	13	3	16
Bismarck, N. Dak.	0.6	0	0	0	0	3	3
Yankton, S. Dak.	—	0	8	8	0	4	4
Omaha, Nebr.	0.7	5	12	17	3	4	7
St. Joseph, Mo.	—	20	0	20	2	0	2
Kansas City, Kans.	—	22	0	22	18	4	22
St. Louis, Mo.	—	24	3	27	29	4	33
Monongahela River: Pittsburgh, Pa.	—	0	0	0	0	0	0
Ohio River:							
East Liverpool, Ohio	—	0	0	0	1	0	1
Huntington, W. Va.	—	0	0	0	0	0	0
Louisville, Ky.	—	1	<1	2	2	0	2
Evansville, Ind.	—	0	0	0	1	2	3
Cairo, Ill.	—	0	0	0	10	3	13
Potomac River:							
Williamsport, Md.	0.8	0	0	0	0	0	0
Red River North: Grand Forks, N. Dak.	1.5	0	0	0	0	2	2
Red River, South:							
Index, Ark.	—	0	0	0	2	0	2
Denison, Tex.	—	0	0	0	0	6	6
Alexandria, La.	—	0	0	0	1	5	6
Rio Grande River:							
Alamosa, Colo.	—	0	6	6	0	1	1
El Paso, Tex.	—	10	11	21	1	12	13
Laredo, Tex.	—	14	0	14	23	3	26
Brownsville, Tex.	0.3	3	0	3	1	4	5
Sabine River: Ruliff, Tex.	0.8	0	0	0	1	0	1
St. Lawrence River: Massena, N. Y.	—	0	0	0	<1	<1	<1
Schuylkill River: Philadelphia, Pa.	—	0	0	0	0	0	0
Savannah River:							
Port Wentworth, Ga.	0.5	<1	73	74	0	0	0
North Augusta, S. C.	0.5	0	0	0	0	[illegible]	0
Snake River: Wawawai, Wash.	—	0	3	3	0	[illegible]	1
South Platte River: Julesburg, Colo.	—	0	30	30	2	[illegible]	24
Susquehanna River:							
Sayre, Pa.	—	0	0	0	0	0	0
Conowingo, Md.	—	0	3	3	0	1	1

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

[Concentrations in μμc/liter]

Station	Quarter ending June 30, 1961	June 1961					
	Strontium-90	Beta activity			Alpha activity		
		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Tennessee River:							
Chattanooga, Tenn.	—	0	50	50	1	0	1
Bridgeport, Ala.	0.9	0	86	86	0	0	0
Yakima River: Richland, Wash.	—	<1	0	<1	<1	0	<1
Yellowstone River: Sidney, Mont.	0.8	41	2	43	2	1	3

[a] Dash denotes no sample received or no determinations made.

analytical schedules in effect till September 1, 1961.

Additional information and data may be obtained from the following sources:

(1) *National Water Quality Network Annual Compilation of Data*, PHS Publication. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.

(2) "Report on National Water Quality Control Network," submitted by Dr. F. J. Weber, Chief, Division of Radiological Health, PHS, at the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, Vol. 1, May 1959, pages 167-169.

(3) Setter, L. R., Regnier, J. E., and Diephaus, A., "Radioactivity of Surface Waters in the United States," J. AWWA *51*, 1377 (1959).

(4) Straub, C. P., Setter, L. R., Goldin, S., and Hallbach, P. F., "Strontium-90 in Surface Waters," J. AWWA *52*, 756 (1960).

(5) Setter, L. R., and Baker, S. L., "Radioactivity of Surface Waters in the United States," *Radiological Health Data*, Vol. I, No. 7 (1960).

Strontium-90 in Tap Water

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Atomic Energy Commission's Health and Safety Laboratory performs analyses for strontium-90 concentrations in tap water for Richmond, California, and New York City on a monthly basis. Previous data were presented in *Radiological Health Data*, Volume I, Numbers 1, 5, and 9, and Volume II, Numbers 4 and 9. Table 1 gives the data for the first quarter 1961 and the yearly averages for 1959 and 1960.

TABLE 1.—STRONTIUM-90 IN TAP WATER[1]
FIRST QUARTER 1961

Location	Month	Activity (μμc/liter)
Richmond, California (40 liters per sample)	Average 1959	0.29
	Average 1960	0.26
	January 1961	0.29
	February	0.32
	March	0.33
New York City (100-200 liters per sample)	Average 1959	0.40
	Average 1960	0.47
	January 1961	0.36
	February	0.31
	March	0.37

[1] Data from *Quarterly Summary Report, HASL*-115, dated October 1, 1961.

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SECTION V. — OTHER DATA

External Gamma Activity

Radiation Surveillance Network, Public Health Service

Portable survey instruments are available at stations of the Radiation Surveillance Network for recording levels of external gamma radiation. Measurements are made daily approximately three feet above the ground. These readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The values shown in the following table do not show an increase in the external gamma levels as a result of atmospheric nuclear weapons testing.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, SEPTEMBER 1961

Station location	Average (mr/hr)	Station location	Average (mr/hr)
Anchorage, Alaska	0.01	Minneapolis, Minn	0.01
Fairbanks, Alaska	0.01	Pascagoula, Miss	0.01
Juneau, Alaska	0.01	Jefferson City, Mo	0.01
Phoenix, Ariz	0.02	Helena, Mont	0.03
Little Rock, Ark	0.01	Trenton, N. J	0.02
Berkeley, Calif	0.01	Santa Fe, N. Mex	0.03
Los Angeles, Calif	0.02	Albany, N. Y	0.03
Denver, Colo	0.02	Gastonia, N. C	0.02
Hartford, Conn	0.01	Bismarck, N. D	0.01
District of Columbia	0.02	Oklahoma City, Okla	0.01
Jacksonville, Fla	0.03	Ponca City, Okla	0.04
Miami, Fla	0.02	Portland, Oreg	0.02
Atlanta, Ga	0.02	Harrisburg, Pa	0.01
Honolulu, Hawaii	0.03	Providence, R. I	0.02
Boise, Idaho	0.02	Columbia, S. C	0.02
Springfield, Ill	0.01	Pierre, S. D	0.02
Indianapolis, Ind	0.01	Nashville, Tenn	0.01
Iowa City, Iowa	0.02	Austin, Tex	0.01
Topeka, Kans	0.02	El Paso, Tex	0.02
Frankfort, Ky	0.01	Salt Lake City, Utah	0.02
New Orleans, La	0.01	Richmond, Va	0.01
Baltimore, Md	0.02	Seattle, Wash	0.01
Lawrence, Mass	0.02	Madison, Wis	0.02
Lansing, Mich	0.02	Cheyenne, Wyo	0.02

Registration of Radiation Producing Machines in the State of New Jersey

Radiological Health Program
New Jersey Department of Health

In 1958, the New Jersey State legislature enacted the "Radiation Protection Act" (Chapter 116, Public Law 1958). Among other provisions, it required the registration of *all* radiation sources. The first registration of *radiation producing machines* was begun during November 1959 and was in effect from December 1, 1959, for an indefinite period. The following tables present the results of the registration of *radiation producing machines* as of July 23, 1961. These tables give the age, type, and the use of the machines according to professional category of the user. The registration of *radioactive materials* was required during April 1960.

TABLE 1.—TYPES OF RADIATION PRODUCING MACHINES

Category	Radiographic	Fluoroscopic	Radiographic and fluoroscopic	Therapeutic	Electron microscope	Particle accelerator	Spectroscope or fluoroscopic unit	Other	Total	Percent of total
Industry	204	4	33	0	18	13	96	306	674	9.9
Physicians	321	446	888	161	0	0	0	1	1,817	26.7
Dentists	2,975	0	0	0	0	0	0	0	2,975	43.8
Chiropractors	172	1	18	0	0	0	0	0	191	2.8
Chiropodists	174	0	3	0	0	0	0	0	177	2.6
Veterinarians	71	2	45	1	0	0	0	0	119	1.8
Institutions	405	76	217	95	0	0	0	0	793	11.7
Schools	24	3	3	0	2	7	11	1	51	0.7
Total	4,346	532	1,207	257	20	20	107	308	6,797	
Percent of total	63.9	7.8	17.8	3.8	0.3	0.3	1.6	4.5		100

TABLE 2.—USES OF RADIATION PRODUCING MACHINES

Category	Diagnostic	Therapeutic	Diagnostic & therapeutic	Industrial	Not stated	Total	Percent of total
Industry	74	0	0	600	0	674	9.9
Physicians	1,644	165	5	0	3	1,817	26.7
Dentists	2,975	0	0	0	0	2,975	43.8
Chiropractors	190	0	1	0	0	191	2.8
Chiropodists	177	0	0	0	0	177	2.6
Veterinarians	117	2	0	0	0	119	1.8
Institutions	698	95	0	0	0	793	11.7
Schools	21	0	0	30	0	51	0.7
Total	5,896	262	6	630	3	6,797	
Percent of total	86.7	3.9	0.1	9.2	0.04		100

TABLE 3.—AGE OF RADIATION PRODUCING MACHINES

Category	Prior to 1930	1930-1939	1940-1949	1950-1959	1960-1961	Not stated	Total	Percent of total
Industry	2	3	116	364	45	144	674	9.9
Physicians	17	94	614	932	75	85	1,817	26.7
Dentists	123	364	965	1,167	276	80	2,975	43.8
Chiropractors	2	4	29	124	25	7	191	2.8
Chiropodists	0	3	41	125	5	3	177	2.6
Veterinarians	0	2	33	52	3	29	119	1.8
Institutions	8	42	222	405	88	28	793	11.7
Schools	3	1	12	21	6	8	51	0.7
Total	155	513	2,032	3,190	523	384	6,797	....
Percent of total	2.3	7.5	29.9	46.9	7.7	5.6	....	100

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Survey of Radioactivity in Animal Feeds

Food and Drug Administration

A part of the continuing surveillance of radioactivity in foods by the Food and Drug Administration is concerned with the levels of strontium-90 and cesium-137 in animal feeds. The following table presents the results of feeds collected in 1960 by representatives of the Food and Drug Administration Districts. Previous data concerned with levels of radioactivity in animal feeds and fodders were given in *Radiological Health Data,* Volume I, Numbers 2 and 9, and Volume II, Number 9.

TABLE 1.—RADIOANALYSES OF ANIMAL FEEDS, 1960

[Concentrations in μμc/kg original material]

Product	County or City	State	Date harvested or processed	Cs^{137}	Sr^{90}
Alfalfa hay	Boulder	Colo.	August	------------	98
Alfalfa hay	Boulder	Colo.	July	------------	41
Alfalfa hay	Larimer	Colo.	July	------------	65
Alfalfa hay	Conejos	Colo.	August	------------	61
Alfalfa hay	Roanoke	Va.	September	------------	231
Lespedeza hay	Washington	Va.	October	------------	529
Lespedeza hay	Berry	Mo.	September	------------	960
Lespedeza Hay	Wake	N. C.	September	------------	447
Peanut hay	Hertford	N. C.	October	------------	507
Peanut hay	Edgecombe	N. C.	October	------------	912
Peanut hay	Irwin	Ga.	August	------------	733
Dried beet pulp	Grant	Kans.	November	------------	3.8
Dried beet pulp	Washakie	Wyo.	October	------------	55
Dried beet pulp	Logan	Colo.	October	------------	52
Cotton seed meal	Tulare	Calif.	November	------------	12
Cotton seed meal	Terry, Garza, Lynn, Lubbock, Hockley, Crosby	Tex.	October	------------	3.1
Grass	Montgomery	Md.	July 18	194	145
Hay	Howard	Md.	June 1	N.D.[1]	
Corn silage	Dunn	Wis.	August, September, October	2.7	
Cotton seed meal	Raleigh[2]	N. C.	July 14	81	
Cotton seed meal	Chow Chilla[2]	Calif.	Jan. 20, 1961	34	
Cotton seed meal	Shafter[2]	Calif.	November	531	
Soyabeans	Sibley & Scott	Minn.	October	N.D.	17
Sugar beet pulp	Grant	Kans.	Nov. 17	1.1	3.8

[1] N.D.—Not detectable.
[2] Processing location.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission transmits to the Public Health Service quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

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Summaries of the environmental radioactivity data for 18 AEC installations have appeared in *Radiological Health Data*, Volume I, Numbers 8 and 9; and Volume II, Numbers 1 through 11. Summaries follow for Argonne National Laboratory, Atomics International, and Feed Materials Production Center, for the first and second quarters of 1961.

The measured concentrations of radioactive substances in air and water may be compared with the Maximum Permissible Concentration (MPC) of that substance as recommended by the National Committee on Radiation Protection and Measurements (NCRP). For the general population, the applicable MPC's are one-tenth of the occupational values for continuous exposure as given in National Bureau of Standards Handbook 69.

For the purpose of clarity and perspective, a few of the applicable environmental MPC values are listed in table 1. Such values are intended as guides only. For further clarification, Handbook 69 should be consulted.

The establishment of MPC's does not imply that each nuclide may be present at 100% of its MPC concentration. If the concentration of each nuclide is expressed in terms of percent of its MPC, then the sum of all the percent values should not exceed 100%.

In the following reports, the use of nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic analyses necessary to justify a less restrictive value. References to table 1 will be made to designate the appropriate MPC's if reported by the laboratory.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line no.	Radioactive substance	Environmental MPC's	
		Water ($\mu\mu c$/liter)	Air ($\mu\mu c/m^3$)
1	Cerium-144	10,000	300
2	Cesium-137	20,000	500
3	Cobalt-58	90,000	2,000
4	Cobalt-60	30,000	300
5	Iodine-131	2,000	300
6	Plutonium-239	5,000	0.06
7	Ruthenium-106-rhodium-106	10,000	200
8	Strontium-90	100	10
9	Thorium-234-protactinium-234	20,000	1,000
10	Uranium-natural	20,000	2
11	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[1]	3,000	----------
12	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[1]	600	----------
13	If Ra^{226}, Ra^{228} are not present[1]	100	----------
14	Mixture of unidentified nuclides	10	0.04
15	If α emitters and Ac^{227} are not present[1]	----------	1.0
16	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present[1]	----------	10
17	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present[1]	----------	100

[1] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to recent FRC recommendations a group of nuclides may be considered not present if the ratio of each nuclide is equal to or less than 1/10 of its appropriate MPC and if the sum of these ratios for the group in question is equal to or less than 1/4.

Argonne National Laboratory

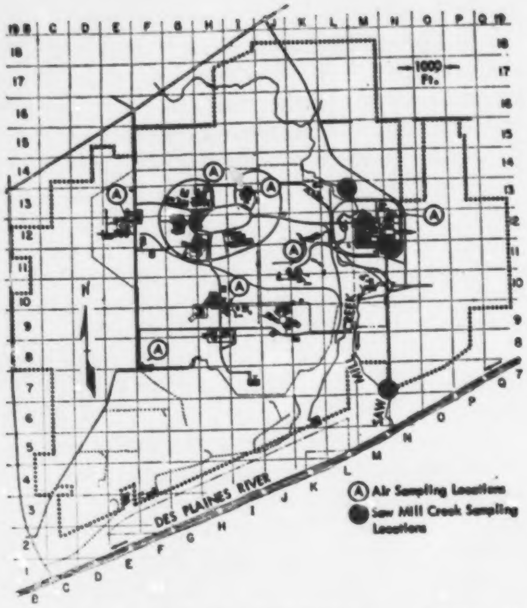
University of Chicago
Lemont, Illinois

Issued September 1961

Environmental levels of radioactivity at the Argonne National Laboratory (ANL) for 1959 and 1960 were reported in *Radiological Health Data*, Volume I, Number 9 and Volume II, Numbers 4 and 7 The following report presents a summary of the data for the first and second quarters of 1961.

Air Monitoring

Air filter samples were collected continuously at seven locations on the ANL site as shown in figure 1 and at four off-site locations at Aurora (west of ANL site), Hinsdale (northeast), Joliet (southwest), and Tinley Park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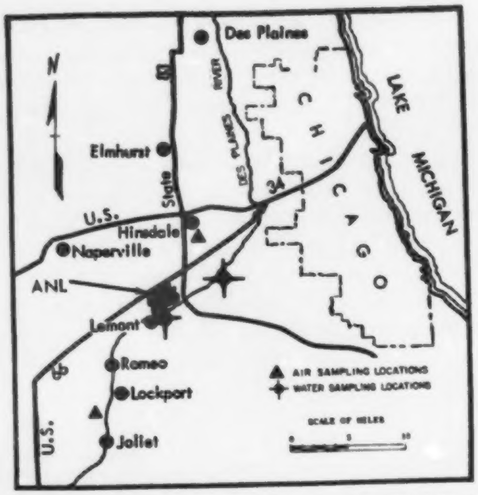
N
Ⓐ Air Sampling Locations
● Saw Mill Creek Sampling Locations
DES PLAINES RIVER
SAW MILL CREEK

Figure 1.—ON-SITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

(southeast). The quarterly averages of alpha, beta, and several nuclide concentrations are given in table 2.

The data shows little difference between off-site and on-site measurements for alpha activity and most of the nuclides indicating that ANL does not contribute significant quantities of these activities to the atmosphere. However, a significant difference in on-site and off-site beta activity correlates with the


Des Plaines
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Elmhurst
Hinsdale
Naperville
ANL
Lemont
Romeo
Lockport
Joliet
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State
DES PLAINES RIVER
34
CHICAGO
LAKE MICHIGAN
U.S.
AIR SAMPLING LOCATIONS
WATER SAMPLING LOCATIONS
SCALE OF MILES
0 5 10

Figure 2.—SITE LOCATION OF ARGONNE NATIONAL LABORATORY (INCLUDING SOME OFF-SITE SAMPLING STATIONS)

even more significant difference for iodine-131 for the first quarter.

During February and March considerable quantities of I^{131} were released to the atmosphere in the exhaust air from two of the ANL buildings. The highest concentration, 16.7 $\mu\mu c/m^3$ (5.6% of environmental MPC) was recorded on March 17 near one of the points of release. During February, the I^{131} concentrations in off-site filter samples were below the minimum level of detection, (0.035 $\mu\mu c/m^3$). Two of the four off-site stations did record some activity during March, the higher of the

Table 2.—ACTIVITIES IN AIR FILTER SAMPLES, ANL

Type of activity	Relative location	First quarter 1961		Second quarter 1961	
		Number of samples	Average concentration ($\mu\mu c/m^3$)	Number of samples	Average concentration ($\mu\mu c/m^3$)
Total alpha	On-site	73	0.0035	78	0.0041
	Off-site	42	0.0035	47	0.0041
Total beta	On-site	73	0.103	78	0.117
	Off-site	42	0.052	47	0.104
Ce^{144}	On-site	73	0.0086	78	0.013
	Off-site	42	0.0084	47	0.012
Cs^{137}	On-site	73	0.0085	78	0.012
	Off-site	42	0.0080	47	0.009
I^{131}	On-site	73	1.7	78	<0.035
	Off-site	42	0.078	47	<0.035
$Ru^{106}Rh^{106}$	On-site	73	0.065	78	0.075
	Off-site	42	0.063	47	0.068

two concentrations being 0.041 μμc/m³ (0.14% of environmental MPC). During the second quarter all of the samples, both off-site and on-site, showed I^{131} concentrations to be less than 0.035 μμc/m³.

Neglecting the effect from I^{131}, the second quarter beta activity was roughly twice that recorded during the first quarter. This was true at all sampling locations, and is attributed to the usual Spring increase in the fallout rate of stratospheric debris from past nuclear detonations.

Water Monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters in the Des Plaines River about 500 yards downstream from the waste water discharge. Sampling locations on Sawmill Creek and Des Plaines River are shown in figures 1 and 2 respectively.

On Sawmill Creek samples are collected weekly upstream and three times a week downstream from the waste water outfall. The upstream flow is roughly equal to the waste water flow yielding a dilution factor of one half. The data in table 3 show significantly higher concentrations downstream than upstream, a clear indication of the radioactivity contributed to the stream by ANL. A comparison of the downstream concentrations with the environmental MPC's listed in table 1 shows that all concentrations are quite low. The highest percent of MPC is that for Sr^{90} for the first quarter, 1.6%.

The data in table 4 do not show any significant difference in activity in Des Plaines River samples taken upstream and downstream from its junction with Sawmill Creek.

Soil and Grass Analysis for Iodine-131

Samples of surface soil and grass were collected on March 29 and 30, primarily to assess the deposition of iodine-131 to these materials from the I^{131} concentrations in air occurring during February and March. In order to relate the soil and grass data with that of air, the concentrations as measured on the date of collection were extrapolated back to March 17, the date that the highest I^{131} concentration was found in air samples. The measured and extrapolated values are tabulated in table 5. The sample location codes refer to the grid markings in figure 1. Off-site locations were

TABLE 3.—ACTIVITIES IN SAWMILL CREEK UPSTREAM AND DOWNSTREAM FROM WASTE WATER OUTFALL ANL

[Average concentrations in μμc/liter]

Type of activity	Sampling location	First quarter 1961		Second quarter 1961	
		Number of samples	Concentration	Number of samples	Concentration
Total alpha	Upstream	13	2.3	13	2.0
	Downstream	39	7.7	38	8.7
Total beta	Upstream	13	6.9	13	6.6
	Downstream	39	20.5	38	24.0
U-natural	Upstream	7	1.3	6	1.3
	Downstream	39	6.4	38	6.9
Pu^{239}	Upstream	3	<0.05	3	<0.05
	Downstream	39	0.08	38	0.06
Th^{234}-Pa^{234}	Upstream	7	1.0	3	1.0
	Downstream	39	5.1	38	6.0
Sr^{90}	Upstream	3	<0.5	3	<0.5
	Downstream	39	1.6	38	1.4
Cs^{137}	Upstream	3	<0.5	3	<0.5
	Downstream	30	1.7	38	2.7
I^{131}	Upstream	4	<2.0	3	<2.0
	Downstream	39	10.8	38	<2.0
Co^{60}	Upstream	2	<1.0	0	----------
	Downstream	12	1.0	0	----------
Co^{58}	Upstream	3	<10	1	<10
	Downstream	39	<10	23	81

TABLE 4.—ACTIVITIES IN THE DES PLAINES RIVER UPSTREAM AND DOWNSTREAM FROM SAWMILL CREEK, ANL

[Average concentrations in μμc/liter]

Type of activity	Sampling location	First quarter 1961		Second quarter 1961	
		Number of samples	Average concentration	Number of samples	Average concentration
Total alpha	Upstream	8	2.2	12	2.4
	Downstream	8	2.2	13	2.2
Total beta	Upstream	8	9.4	12	8.9
	Downstream	8	9.5	13	9.0
U-natural	Upstream	4	1.4	6	1.7
	Downstream	8	1.5	13	1.7
I^{131}	Upstream	0	------	1	<1.0
	Downstream	2	<1.0	2	<1.0

TABLE 5.—IODINE-131 ACTIVITY IN SOIL AND GRASS, ANL, 1961

[Concentrations in μμc/gram]

Location (*See fig. 1*)	Samples collected March 29 and 30				Concentrations in grass on dates of collection		
	Concentration at time of collection		Calculated concentration extrapolated back to March 17				
	Soil	Grass	Soil	Grass	May 11, 12	June 5	June 28
12 G	27 (4)	5,650	85 (4)	17,850 (4)	7.3 (4)	2.7 (4)	—
12 H	10 (4)	862	31 (4)	2,670 (4)	—	—	—
11 G	6.5	616	20	1,740	—	—	—
10 H	<0.3	376	<1	1,140	26.0	7.0 (4)	1.0 (4)
11 B	<0.3	5	<1	18	—	—	—
15 F	<0.3	<1	<1	<3.7	—	—	—
15 L	<0.3	<1	<1	<3.7	—	—	—
6 K	<0.3	4.9	<1	15	—	—	—
12 E	<0.3	23	<1	70	—	—	—
All off site points	—	<1 (5)	—	<3.7 (5)	—	—	—

— Indicates no samples taken.
Numbers in parentheses indicates number of samples.

Lemont, Joliet, Downers Grove, Lombard, and Tinley Park.

A cursory comparison of the data reveals that grass is a much more sensitive indicator of I^{131} than soil. No I^{131} was detected in soil more than 150 yards from the point of release, southeast corner of square 12G, figure 1. Small amounts of I^{131} were detected in grass samples taken at the western (11B) and southern (6K) edges of the ANL site.

Because of its higher sensitivity only grass samples were taken during May and June as a followup of the March 29-30 test. The May and June data, also shown in table 5 reflect the rapid decay of I^{131} and the much lower air concentrations during that time.

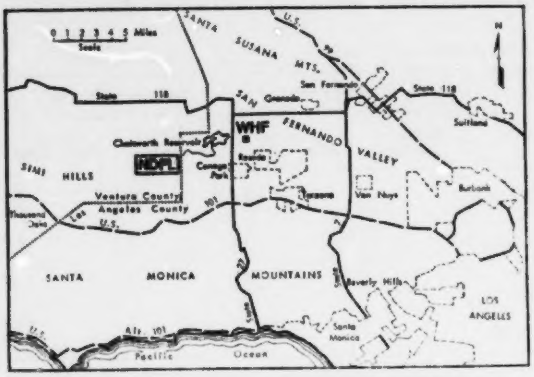
Atomics International

Canoga Park, California
Issued September 1961

Environmental levels of radioactivity at the Atomics International facilities have not been previously reported in *Radiological Health Data*. The following report presents a summary of the data for calendar year 1960, and the first two quarters of 1961.

The Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) are operated for AEC by Atomics International (AI), Canoga Park, California. The locations of the two facilities are shown in figure 3.

The NDFL facilities include a 20 megawatt SRE power reactor; several smaller experi-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Chatsworth Reservoir
NDFL
Reseda
Canoga Park
SIMI HILLS
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
101
U.S.
Thousand Oaks
SANTA MONICA MOUNTAINS
Beverly Hills
LOS ANGELES
Santa Monica
U.S.
Alt. 101
Pacific Ocean
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FIGURE 3.—ATOMICS INTERNATIONAL FACILITIES AND VICINITY

mental reactor facilities such as critical facilities, SNAP reactor, shield test facilities, and others; and extensive rolling and fuel fabrication operations. The major activities at the WHF are of the administrative type. However, a small amount of fuel fabrication is conducted at the site. For that reason the WHF area is included in the Atomics International environmental monitoring program.

Air Monitoring

Environmental air sampling is conducted continuously at the WHF and NDFL sites by automatic twenty-four hour step cycle air monitors. Airborne particulates are collected on a fixed filter tape which is moved, after each twenty-four hour period, to place the new sample beneath a thin window G. M. detector. At pre-set intervals, usually twenty minutes, the number of counts observed by the scaler during the interval is recorded.

It has been determined that for this type of instrument twice the counting rate after 18.6 hours decay minus the counting rate after 8 hours decay closely approximates the long-lived contribution. This counting rate can be converted easily to the average long-lived airborne activity ($\mu\mu c/m^3$) during the sampling period. The minimum detection limit, which varies somewhat between instruments, is on the order of 0.04 $\mu\mu c/m^3$. The average concentrations of long-lived airborne beta emitters are shown in table 6.

When abnormally high activities are observed, the data are plotted to determine the presence of short-lived activities other than radon and thoron daughters. If fallout is suspected, samples are removed to the laboratory where their decay is observed for a period of several days to several weeks. If the activity decays as a function of $t^{-1.2}$, the data is extrapolated in order to find the date of origin. This date is then compared with the dates of announced nuclear detonations in order to demonstrate that the abnormal airborne activity was not caused by Atomics International operations.

Water Monitoring

Two water wells at the Nuclear Development Field Laboratory are sampled monthly. Monthly surface samples are collected at the

TABLE 6.—AVERAGE CONCENTRATIONS OF RADIOACTIVITY IN AIR, WATER, SOIL, AND VEGETATION IN THE ATOMICS INTERNATIONAL ENVIRONMENT

Type of sample	Location	Activity	1960		First quarter 1961		Second quarter 1961	
			No. of samples	Average	No. of samples	Average	No. of samples	Average
Air ($\mu\mu c/m^3$)	WHF	β-γ	182	0.24	95	0.25	47	0.25
	NDFL	β-γ	44	0.44	42	0.40	(a)	------------
Water ($\mu\mu c$/liter)	NDFL wells	α	12	0.14	1	0.05	6	0.085
		β-γ	19	2.0	6	3.6	6	2.5
	Chatsworth Reservoir	α	0	------------	0	------------	15	0.39
		β-γ	0	------------	0	------------	15	7.7
Soil ($\mu\mu c$/gram)	On-site	α	104	0.45	17	0.32	30	0.47
		β-γ	114	23.0	30	37.0	30	35.0
	Off-site	α	324	0.36	45	0.30	112	0.35
		β-γ	360	19.0	96	24.0	112	24.0
Vegetation ($\mu\mu c$/gram ash)	On-site	α	89	0.41	13	0.24	30	0.32
		β-γ	113	136.0	30	167.0	30	152.0
	Off-site	α	281	0.28	48	0.19	113	0.35
		β-γ	358	135.0	96	156.0	113	135.0

[a] Data not available.

Chatsworth Reservoir, owned by the Los Angeles City Department of Water and Power. The average water activity is shown in table 6.

Soil and Vegetation Sampling

Soil and vegetation are sampled monthly at forty-eight locations. Ten of these are within the boundaries of the Atomics International sites; the remaining thirty-eight are within a ten mile radius of the sites. Data for soil and vegetation are shown in table 6.

Surface soil types available for sampling range from decomposed granite to clay and sandy loam. Collected samples represent the top one-half inch layer of ground surface.

Vegetation samples obtained in the field at each station are of the same plant type wherever possible, and are generally sunflower or wild tobacco plant leaves. These plant types maintain an active rate of growth during the dry season, a characteristic uncommon to most other plant types indigenous to the area.

Feed Materials Production Center

National Lead Company of Ohio, Fernald, Ohio
Issued September 1961

Environmental levels of radioactivity at the Feed Materials Production Center (FMPC) for 1959 and 1960 were reported in *Radiological Health Data*, Volume II, Numbers 4 and 6. The following report presents a summary of the data for the first and second quarters of 1961.

The FMPC, located in the Great Miami River Basin in southwestern Ohio, is operated by National Lead Company of Ohio (NLO) for AEC. The location, as related to populated areas, is shown in figure 4.

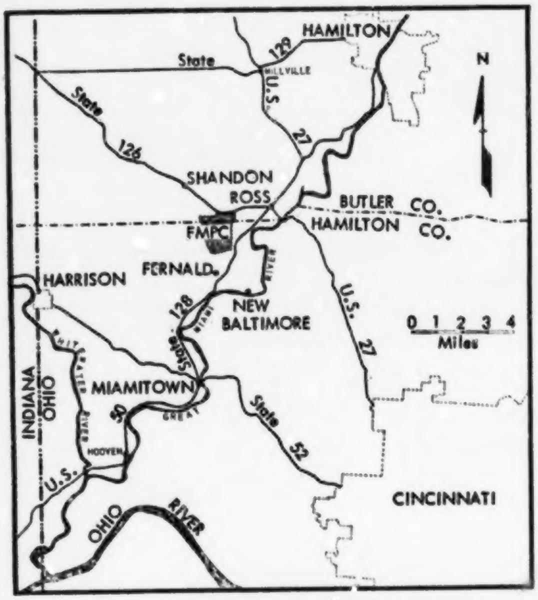

FIGURE 4.—AREA MAP OF FEED MATERIALS PRODUCTION CENTER

Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and the fabrication of the metal into fuel elements. Some details of the processes were reported in the issues referred to above.

To check the effectiveness of dust collectors and waste treatment processes, an environmental survey program of air and water sampling is maintained.

Air Monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitations, and scrubbing towers which remove nearly all of the airborne particulates generated during the many involved processes. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

On-site samples were taken by four permanent sampling stations located at the four corners of the production area shown in figure 5. Off-site samples were taken by a mobile unit operated at various distances and directions from the plant. The data for the off-site samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at on-site and off-site locations are given in table 7.

TABLE 7.—RADIOACTIVITY OF AIRBORNE PARTICULATES, FMPC

[Average concentrations in μμc/m³]

Location	First quarter 1961			Second quarter 1961		
	Number of samples	Uranium	Total activity	Number of samples	Uranium	Total activity
On-site:						
Southwest	3	0.16	0.20	12	0.13	0.56
Northwest	10	0.07	0.14	12	0.09	0.22
Northeast	11	0.13	0.23	12	0.15	0.24
Southeast	11	0.12	0.27	12	0.21	0.33
All on-site samples	35	0.11	0.21	48	0.19	0.35
Off-site:						
0-2 miles from FMPC	6	0.29	0.52	6	0.15	0.28
2-4 miles from FMPC	22	0.21	0.33	18	0.05	0.30
4-8 miles from FMPC	10	0.26	0.43	16	0.13	0.30
8-10 miles from FMPC	2	0.48	0.09	6	0.11	0.37
All off-site samples	40	0.25	0.37	46	0.11	0.30

Water Monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken. Table 8 presents a comparison of the calculated and the spot checked river concentrations. Sampling points are shown in figure 5.

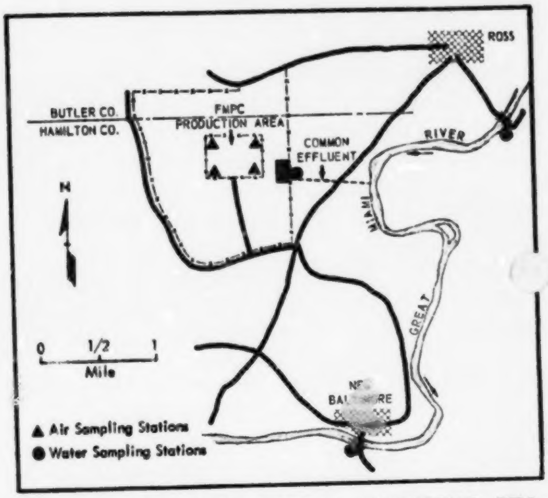

FIGURE 5.—AIR AND WATER SAMPLING STATIONS, FEED MATERIALS PRODUCTION CENTER

TABLE 8.—CONCENTRATIONS OF URANIUM AND TOTAL ACTIVITY IN THE GREAT MIAMI RIVER, OHIO

[Average concentrations in μμc/m³]

Location	Method of determination	First quarter 1961			Second quarter 1961		
		Number of samples	Uranium	Total activity	Number of samples	Uranium	Total activity
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	90	7	5	91	2	3
Upstream	Spot samples	15	10	34	15	12	35
Downstream	Spot samples	15	12	51	15	10	38

Note: Please make the following correction in the November 1961 issue (*Radiological Health Data*, Volume II, No. 11): In footnote 1 of table 3 on page 502 change "20 μμc/liter" to read "20,000 μμc/liter."

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nvironmental Monitoring in Alaska

Project Chariot
Atomic Energy Commission

In May 1959, the United States Atomic Energy Commission approved a program of environmental studies to be conducted in conjunction with a proposed excavation project using nuclear explosives (Project Chariot, Plowshare Program) at the mouth of Ogotoruk Creek in northwestern Alaska.

The proposed project, which is under study and for which the detonations have not been approved, would involve the simultaneous detonation of five nuclear devices. Four 20 kiloton devices would be buried to about 400 feet, and one 200 kiloton device buried to about 800 feet. The detonation would be expected to produce a channel about 900 feet wide and about 2,000 feet long, with an additional basin of about 1,800 feet in diameter resulting from explosion of the larger device. It is expected that about 95 percent of the fission products will be entrapped underground.

fter the USSR resumed testing on September 1, 1961, four fallout monitoring stations were activated at Cape Thompson, Kivalina, Kotzebue and Point Hope, as shown in figure 1. The following tables present the first results from this monitoring.

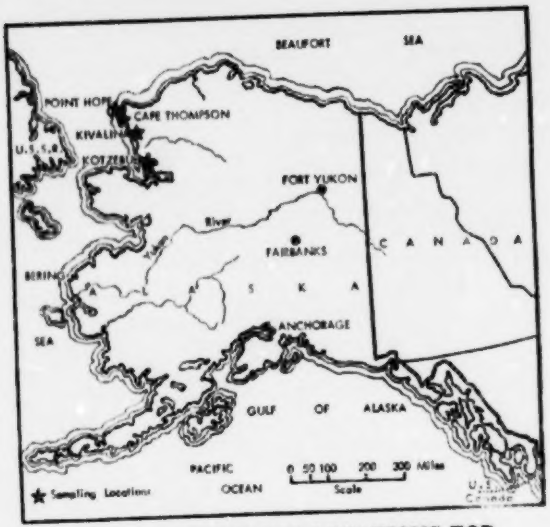

FIGURE 1.—SAMPLING LOCATIONS FOR PROJECT CHARIOT

TABLE 1.—GROSS BETA ACTIVITY IN ALASKAN AIR SAMPLES, SEPTEMBER, 1961

End of sampling period	Cape Thompson		Kivalina		Kotzebue		Point Hope	
	Sampling time (hours)	Gross beta ($\mu\mu c/m^3$)	Sampling time (hours)	Gross beta ($\mu\mu c/m^3$)	Sampling time (hours)	Gross beta ($\mu\mu c/m^3$)	Sampling time (hours)	Gross beta ($\mu\mu c/m^3$)
September 22	16.17	<0.10	2.08	<0.10	----	----	----	----
23	23.25	3.64	2.33	<0.10	----	----	7.00	<0.10
24	29.50	0.15	3.58	0.62	19.92	0.39	13.00	1.78
25	24.33	1.76	4.42	0.71	21.00	0.71	7.00	0.15
26	25.78	1.18	3.42	0.78	24.17	0.67	6.50	5.28
27	23.22	11.2	2.08	44.7	24.08	3.40	14.75	22.2
28	----	----	3.75	7.27	24.17	4.82	15.17	7.80
29	----	----	5.00	5.75	23.25	49.3	12.92	4.50
30	----	----	3.42	17.0	24.17	16.2	11.58	3.20
October 1	----	----	----	----	26.58	16.4	----	----

TABLE 2.—GAMMA SCAN OF ALASKA WATER SAMPLES, SEPTEMBER, 1961

Location	Date of sampling	Type of sample	Ba^{140}-La^{140} ($\mu\mu c$/liter)
Ogotoruk Creek	September 18	Surface water	[a] 470
Kivalina	September 22	Cistern water	240
Kotzebue	September 27	Tap water	<30
Point Hope	September 29	Surface water	<30
Camp Chariot	September 18-21	Rain water	1,300

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[a] Trace amounts of Zr^{95}-Nb^{95} also observed.

Announced Nuclear Detonations

Radiological Health Data, Volume II, Numbers 10 and 11 published the dates of the Union of Soviet Socialist Republics announced nuclear detonations through November 2, 1961. The following table gives information on the last reported test in this series as well as data on reported United States underground tests through December 3, 1961. Low yield range has been announced as meaning about a nominal (20 kiloton) yield; low-intermediate to mean between a nominal and one megaton yield.

Test number	Location	Date	Size	Type of test
		ANNOUNCED U.S.S.R. SHOT		
31	Novaya-Semlya	November 4	Several megatons	Atomospheric
		ANNOUNCED U.S. SHOTS		
1	Nevada Test Site	September 15	Low yield	Underground
2	Nevada Test Site	September 16	Low yield	Underground
3	Nevada Test Site	October 10	Low yield	Underground
4	Nevada Test Site	October 24	Low yield	Underground
5	Nevada Test Site	December 3	Low yield	Underground

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4	April	169–206	10	October	417–470
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